Review for Midterm 1

Agenda

- Finish object recognition
- Review for Midterm 1

Announcements

- Turn in your short papers on titanium
- Green scantron

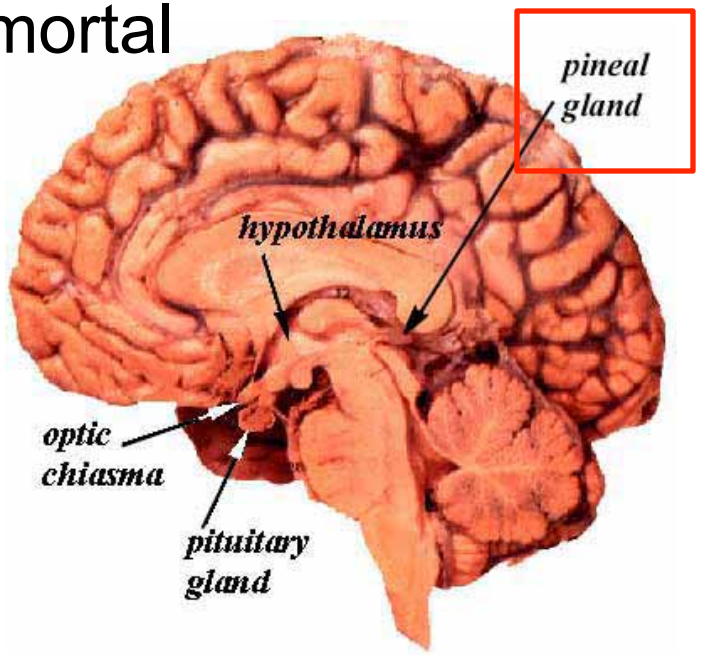
Black Box = 

Cognitive Neuroscience

- Infer what is happening by looking at behavior
  - Behavioral paradigms
- Observe what happens when the box (the brain) is damaged
  - Case studies
- Observe what happens when we mess with the box
  - Brain stimulation
- Can image what is happening inside the box
  - Brain imaging

History: How is mind related to the brain?

- Mind-body problem: how can a physical substance give rise to our feelings, thoughts, emotions?
- Dualism - Rene Descartes (1596-1650)
  - Mind was non-physical (awareness) and immortal
  - Brain was physical and mortal
  - Interact in the…



How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

Subjective

Objective

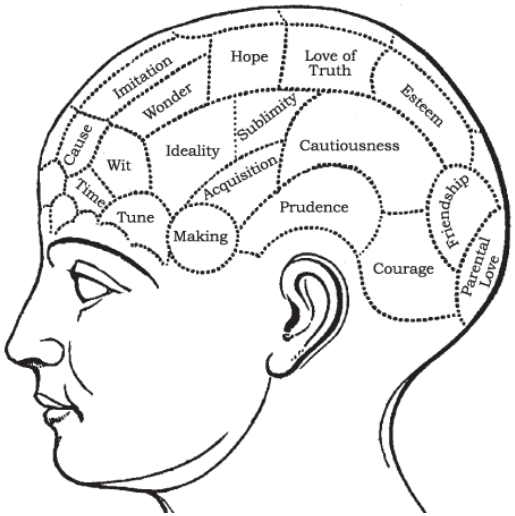
How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

- Reductionism (Churchland, Crick)
  - Mind can be reduced to biological constructs (e.g., patterns of neuronal firing, neurotransmitters)
  - “there is no soul, no mind, only the brain”
  - Only objective

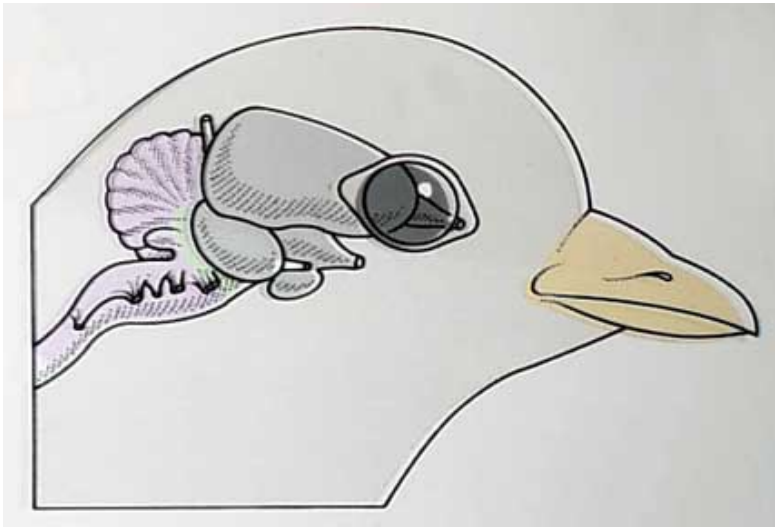
Phrenology (early 19th century)

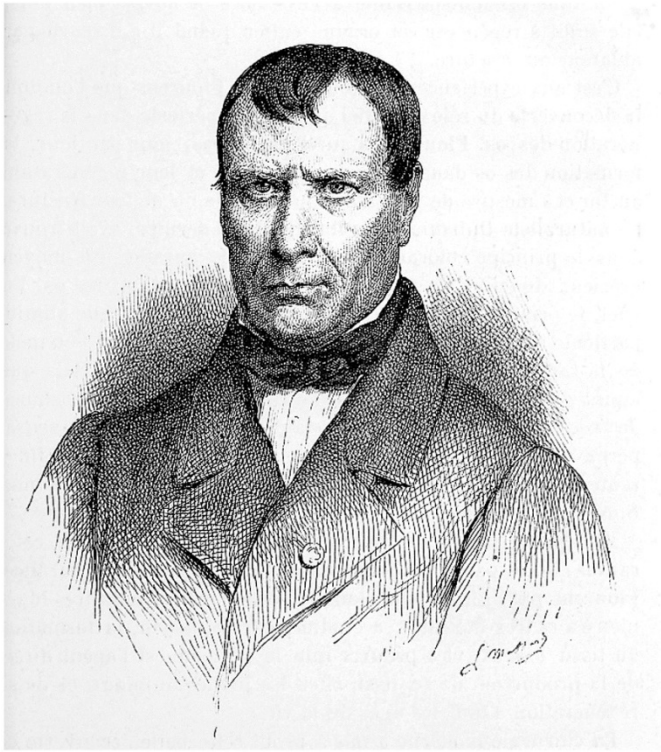
- Led by Franz Gall (1758-1828)
- "Localizationist" view
  - *Cognitive* functions to specific brain regions
  - Idea:
    - Using a mental function caused corresponding brain region to grow bigger,
    - Which created bumps on skull



Localizationism vs Holism

- Aggregate field theory – holism
  - *Whole brain participates in each behavior.*
    - Birds with brain lesions recover no matter where lesion was
    - Lesions did not produce specific deficits.

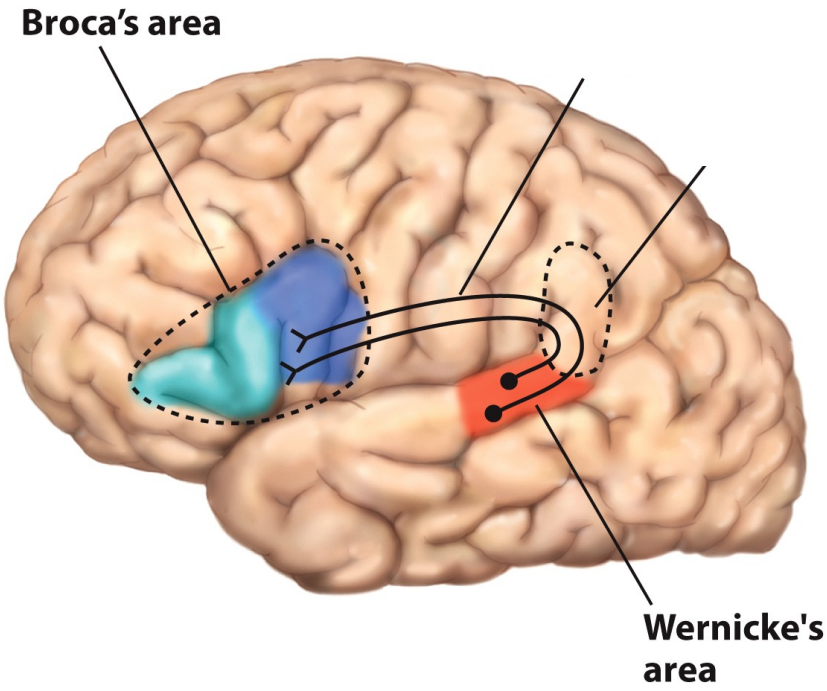




Pierre Flourens

Localizationism (1860s)

- 1861: Paul Broca's patient "Tan"
  - Inability to generate speech *(Broca's aphasia)*
  - Post-mortem autopsy found left anterior region lesion
- 1874: Carl Wernicke
  - Comprehension loss *(Wernicke's aphasia)*
  - Post-mortem autopsy found left posterior region lesion

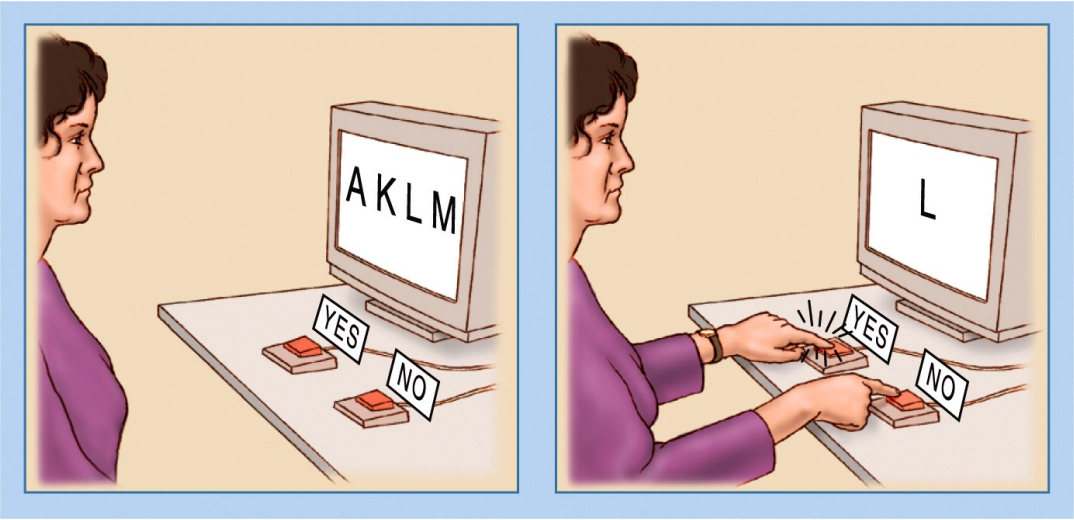


Localizationism vs Holism: Who wins?

- Both were partially right 

- Specific processes can be localized to single brain regions
- BUT complex functions are carried out by many brains regions acting in concert
- Debate continues in almost every domain of study in cognitive neuroscience.

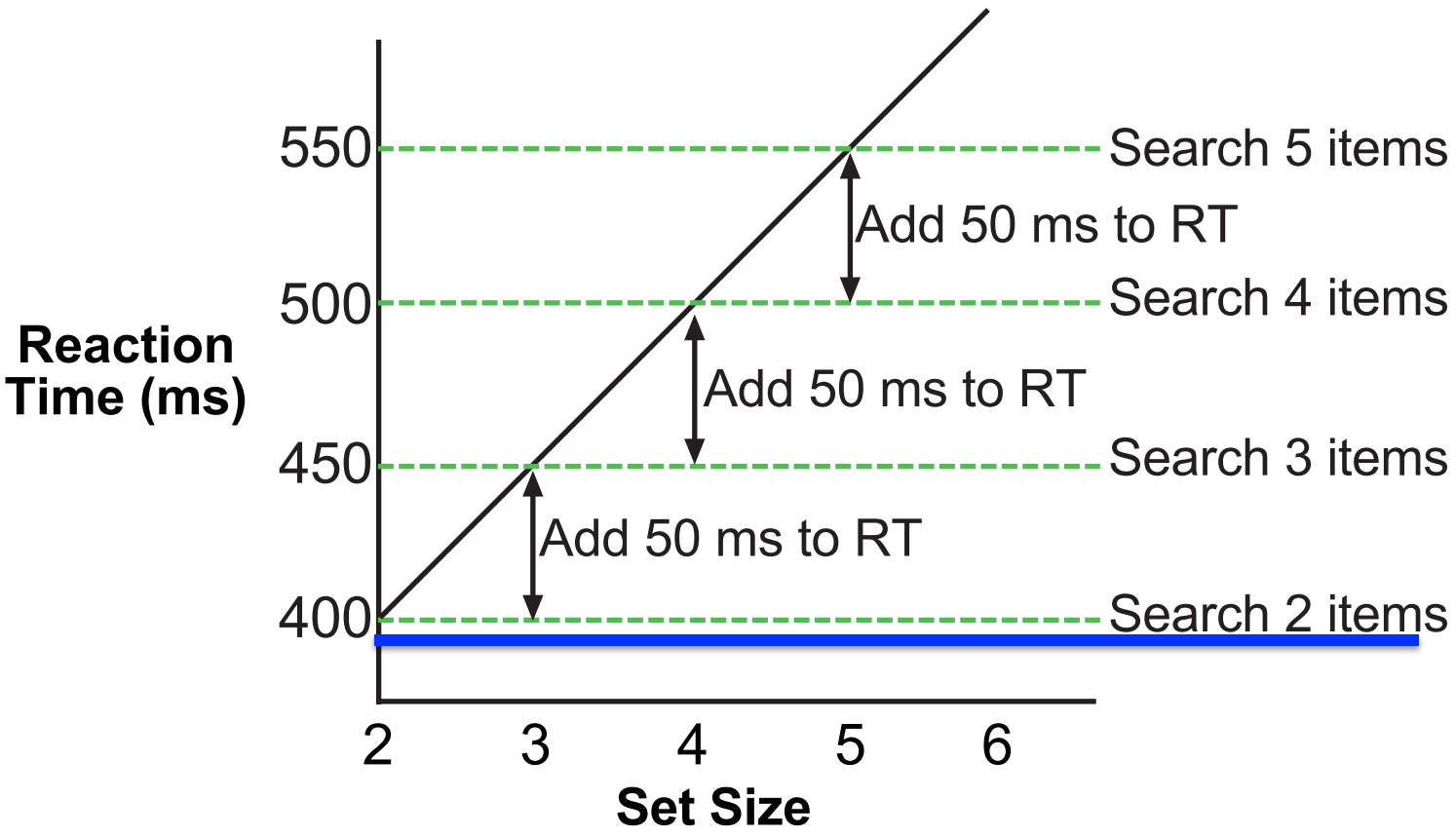
Behavioral paradigm example: Sternberg short-term memory experiment



- Subject sees letters on the screen and then has to decide if a letter came from the group.
-
-

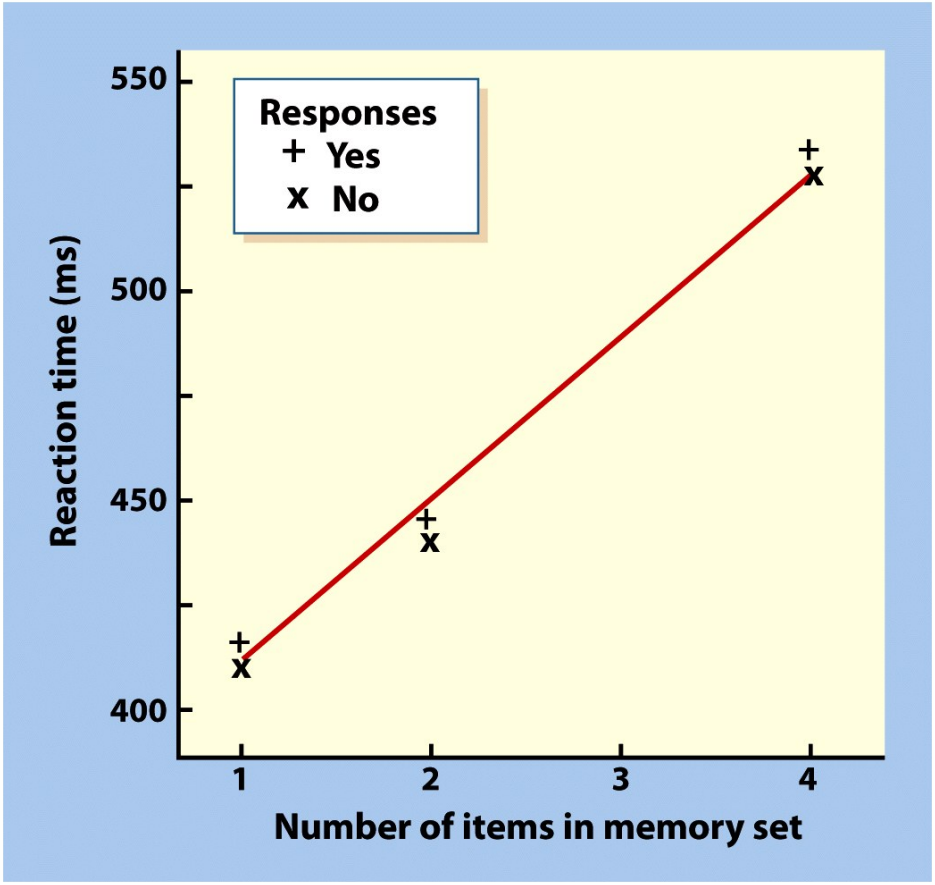
Serial search: linear increase in RT

RT goes up by 50 ms for each item added to the array (Slope = 50 ms/item).



Parallel search: flat RT function

Reaction time increases as a function of learning set!



- Search time is a linear function of the number of items in the memory set
- Search time is the same regardless of whether the probe item was part of the original list (yes/no responses), suggesting an **exhaustive** search.

Conclusions: memory items are scanned serially during memory search

Methods

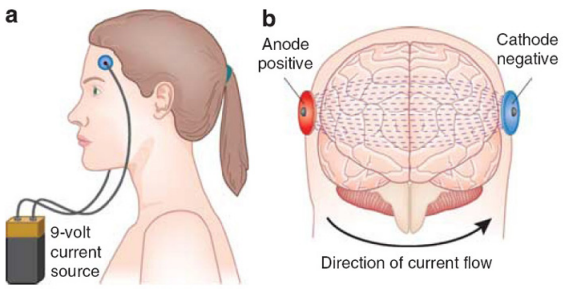
- Invasive – damage to scalp or brain
  - Deep brain stimulation
  - Single cell recording & brain lesions
- Non-invasive – no damage
  - tDCS and TMS
  - EEG and fMRI

Methods

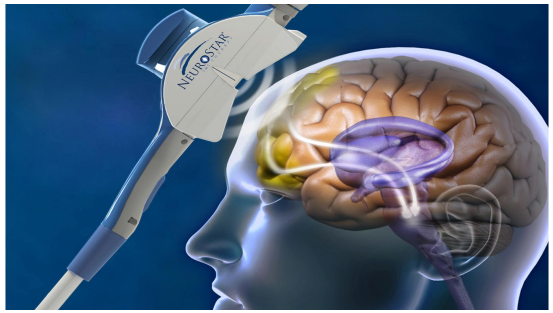
- Direct – actually stimulating/measuring neuron activity
  - Deep brain stimulation
  - Single cell recording
- Indirect – stimulating/measuring brain activity at a larger scale
  - tDCS, TMS
  - fMRI, EEG

Which method is best?

- I want to know the *causal* relationship between occipital lobe and vision
  - Brain stimulation (tDCS, TMS)
- I want to manipulate a deep brain structure non-invasively.
  - tDCS

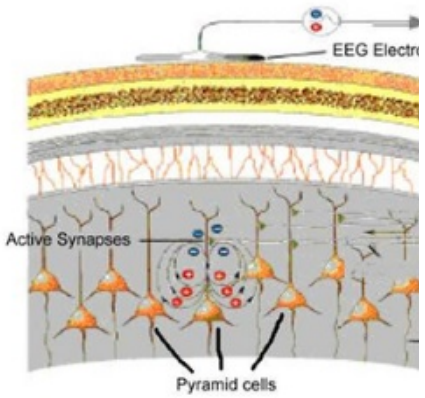


- I want to manipulate a shallow brain structure non-invasively.
  - TMS



Imaging – correlation only

- *When* does a brain function occur?
  - EEG (high temporal resolution)



- *Where* in the brain is used for this function?
  - fMRI (high spatial resolution),

Lesions, brain stimulation, brain imaging of a brain area

	Brain area A Lesion	Brain area B Lesion	
Function C	X	✓	Single dissociatio
Function D	✓	X	Single dissociatio

Together – double dissociation

Lesions, brain stimulation, brain imaging of a brain area

	Brain area A Lesion	Brain area B Lesion	
Function C	X	✓	Single dissociatio
Function D	X	✓	Single dissociatio

Together – two single dissociations
NOT a double dissociation

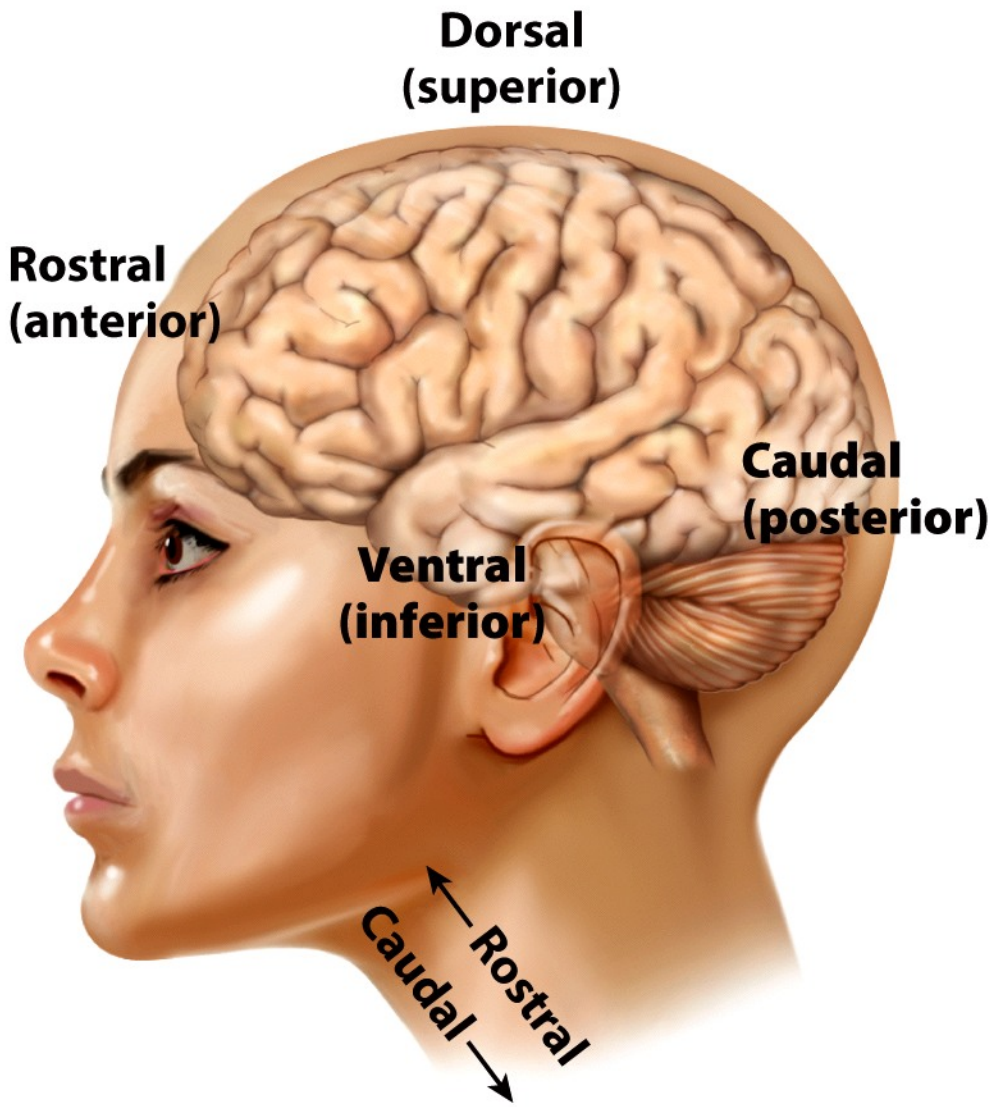
Lesions, brain stimulation, brain imaging of a brain area

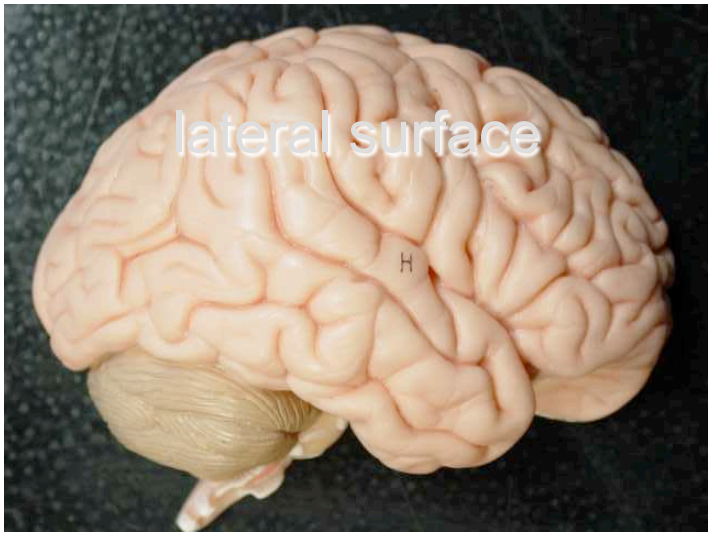
	Broca's area	Wernicke's area
Speech Production	X	✓
Speech Comprehension	✓	X

Single dissociatio

Single dissociatio

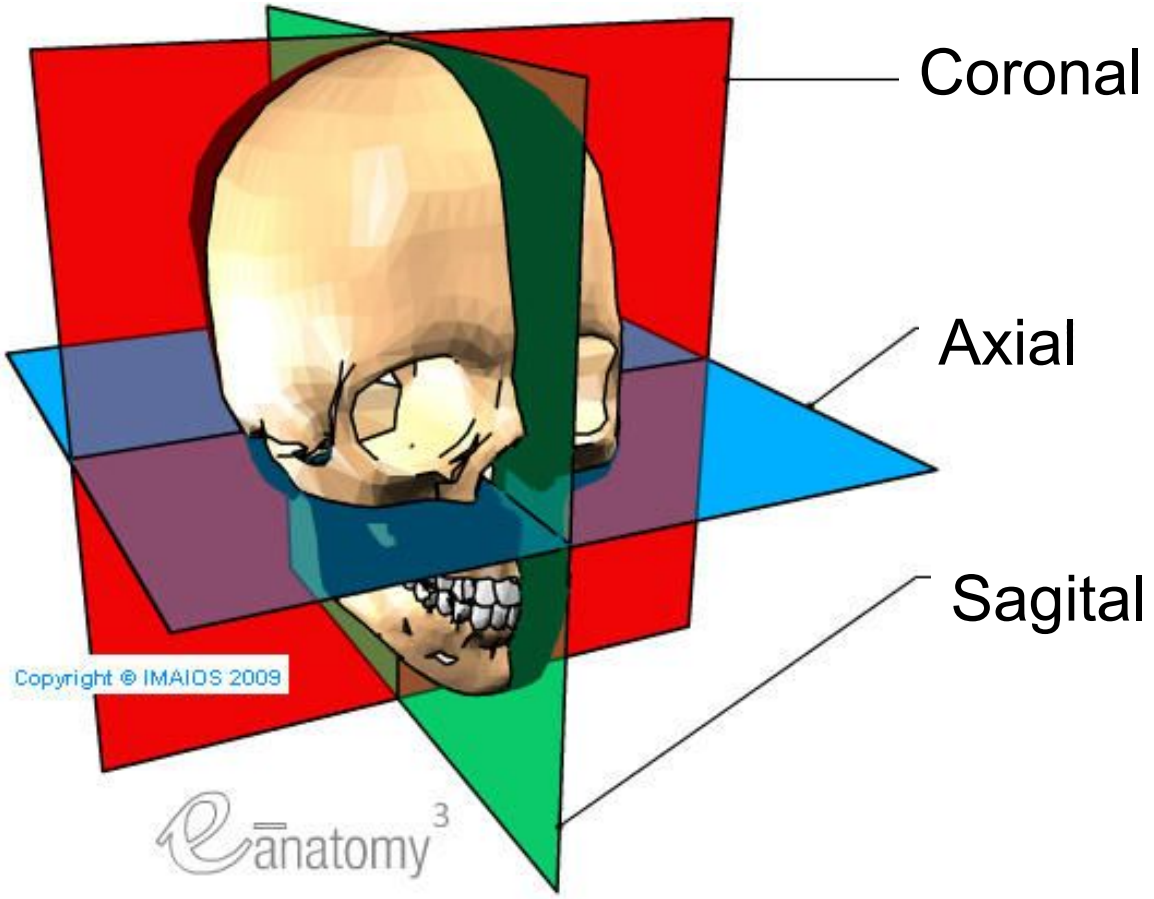
Together – double dissociation


Dorsal
(superior)
Rostral
(anterior)
Caudal
(posterior)
Ventral
(inferior)
Rostral
Caudal



- Lateral: toward the outside.

- Medial: toward the inside (middle).

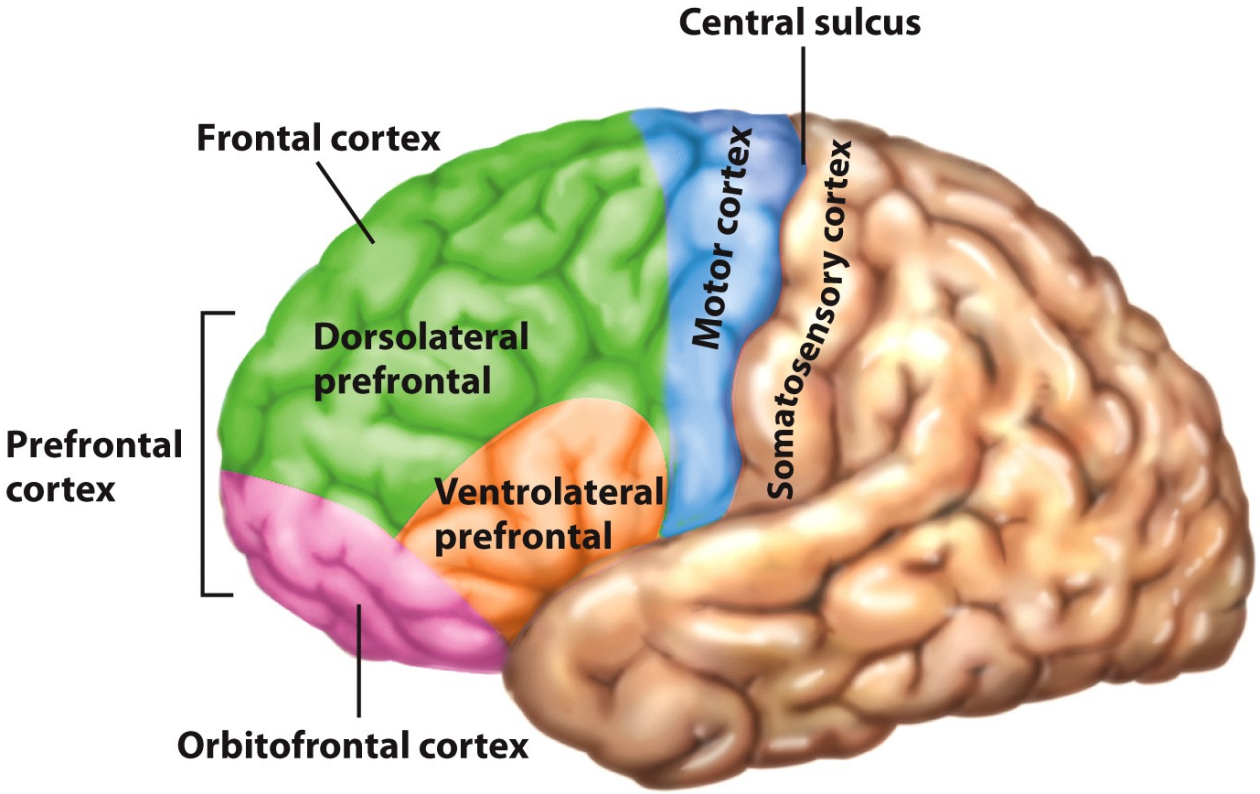


- Sagittal, coronal, and axial planes.

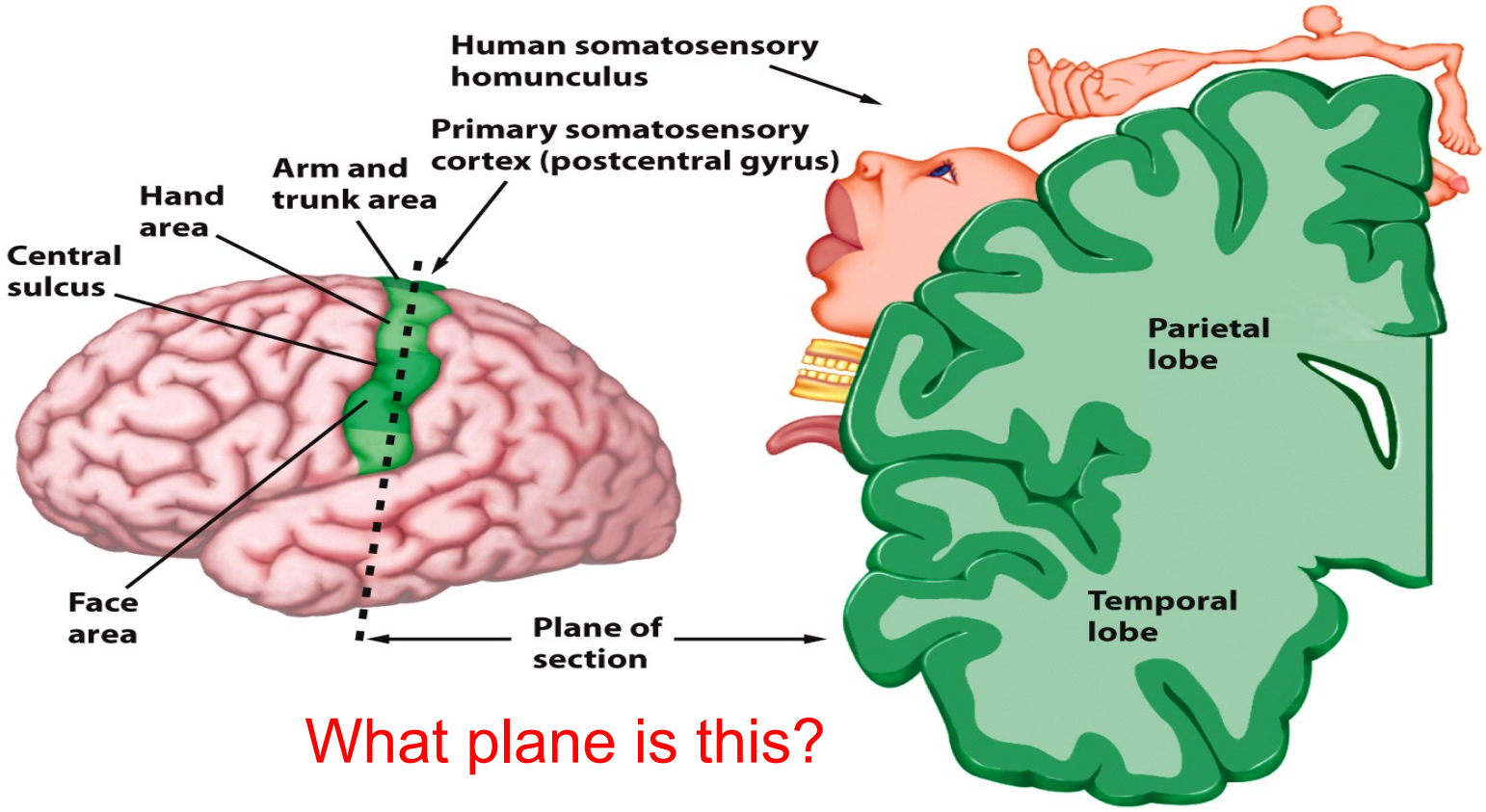
Functional neuroanatomy

- Broadman's area
  - Defined through histology
- Brain
  - Gray and white matter
  - Gyrus and sulcus
  - Lobes
  - Functional subdivision: e.g., within Frontal lobe
- Cortical maps: homunculus
  - Motor cortex and somatosensory cortex

Functional subdivisions of the brain



- Functional subdivisions based on loss of function from lesions or gain of function from stimulation.
- First discuss most basic functions these lobes perform.

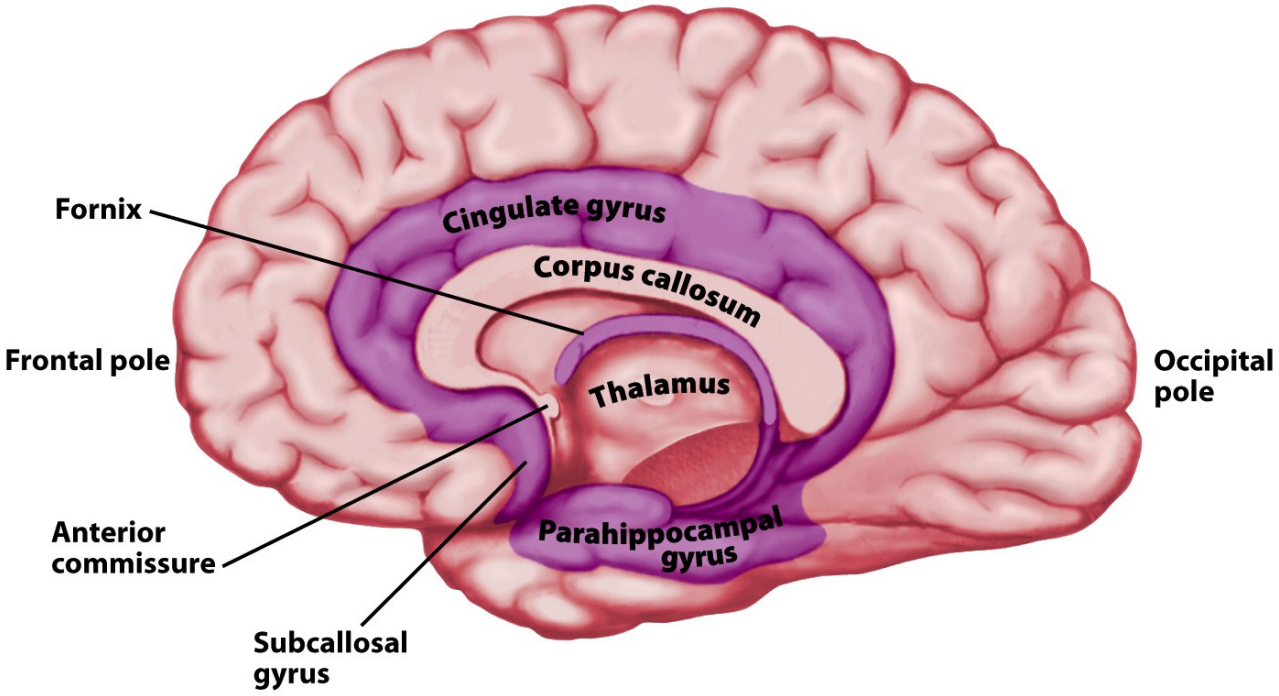


What plane is this?

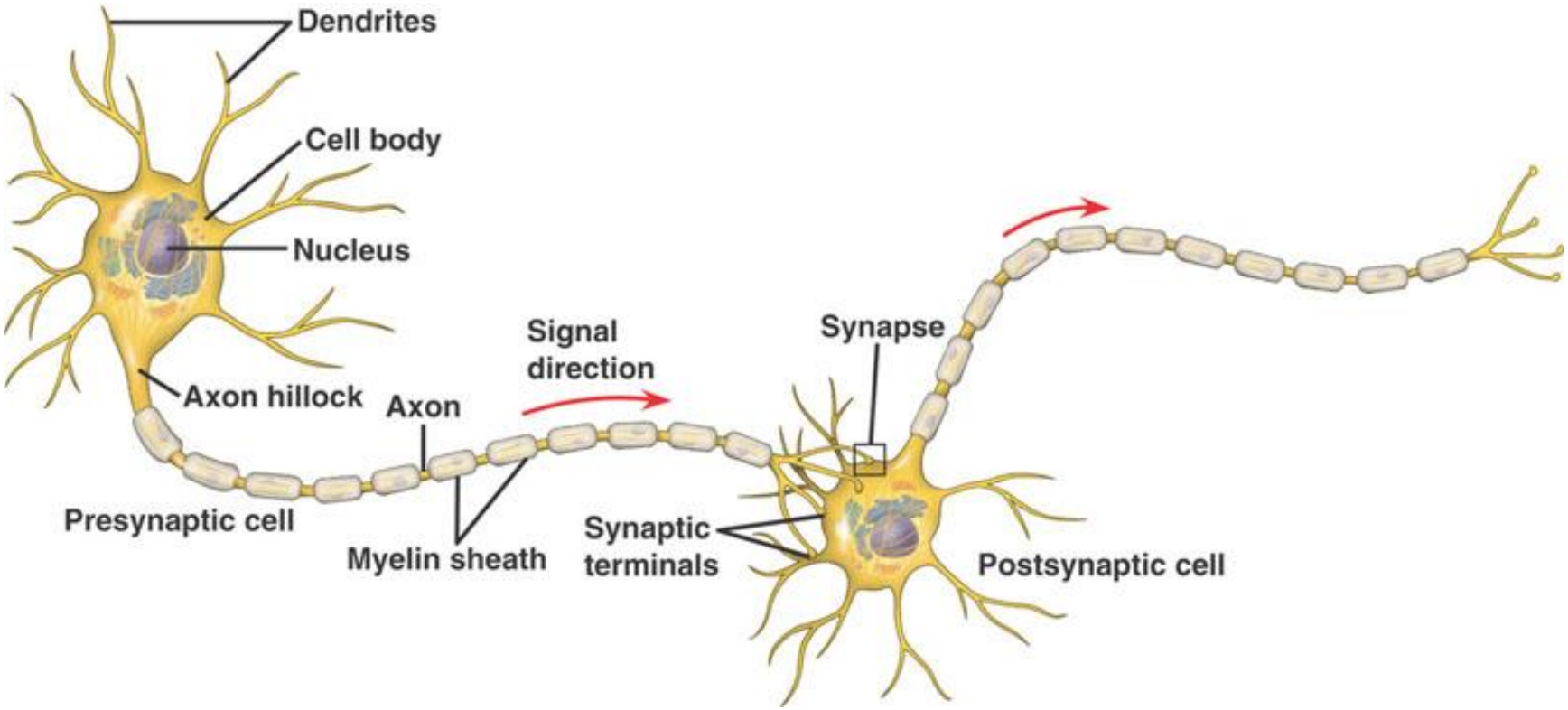
- Our representation of the somatosensory world is mapped onto our brains!
- Topographic correspondence between cortical regions & body surface

Limbic system

- Composed of hippocampus, hypothalamus, parts of thalamus, amygdala, and parts of basal ganglia.
- Limbic system: emotion and behavior, learning, memory

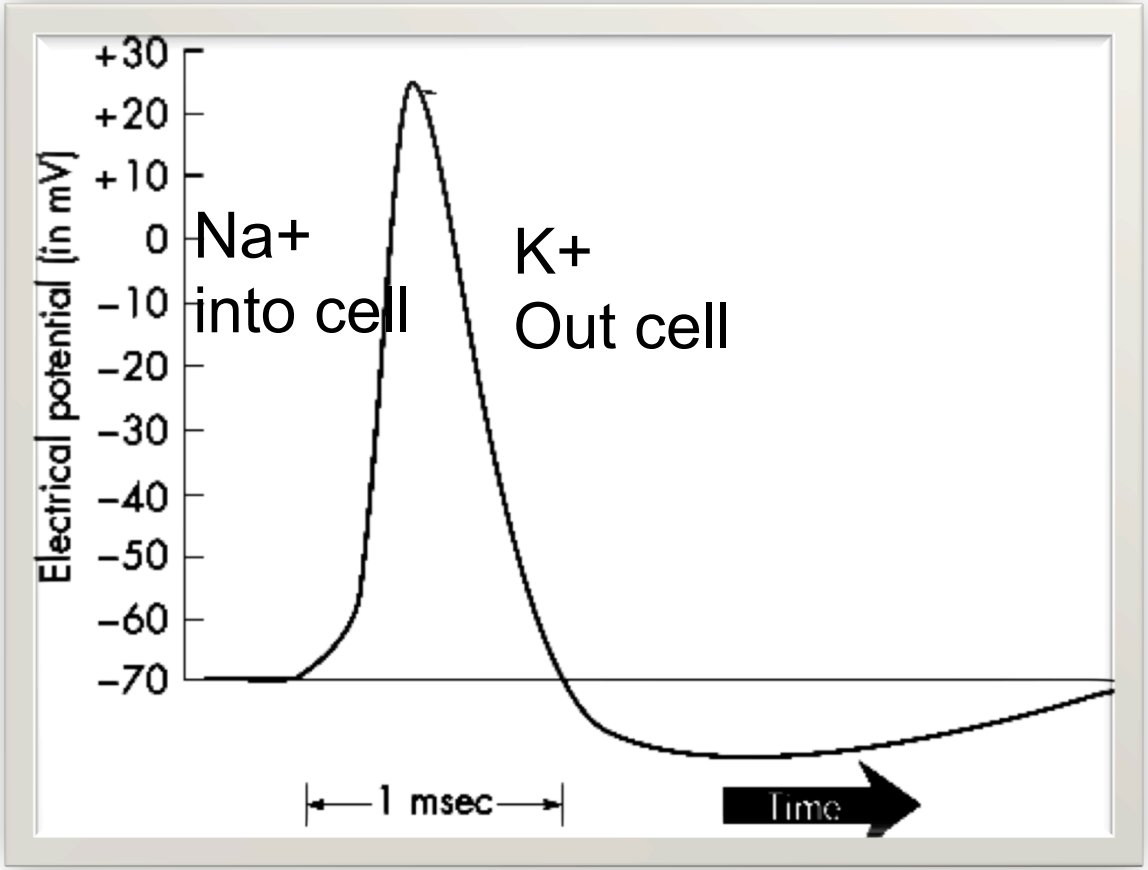


Typical Neuron



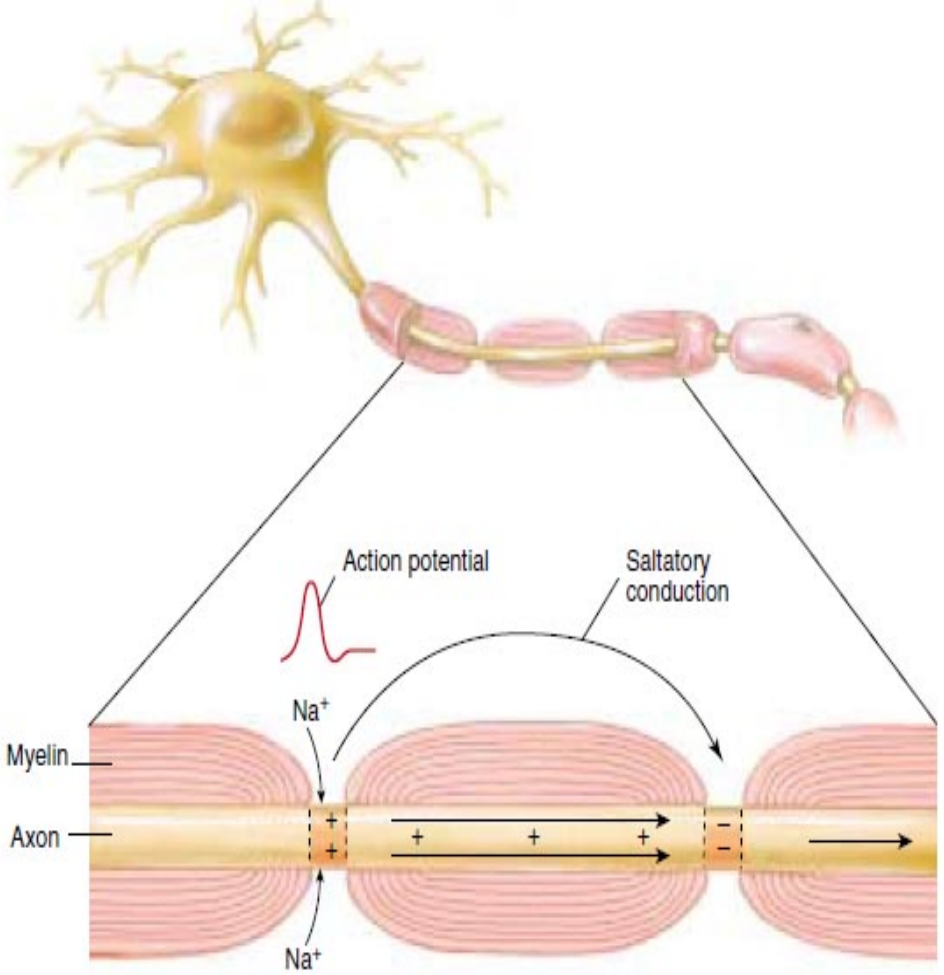
The Action Potential

A neuron no longer at rest

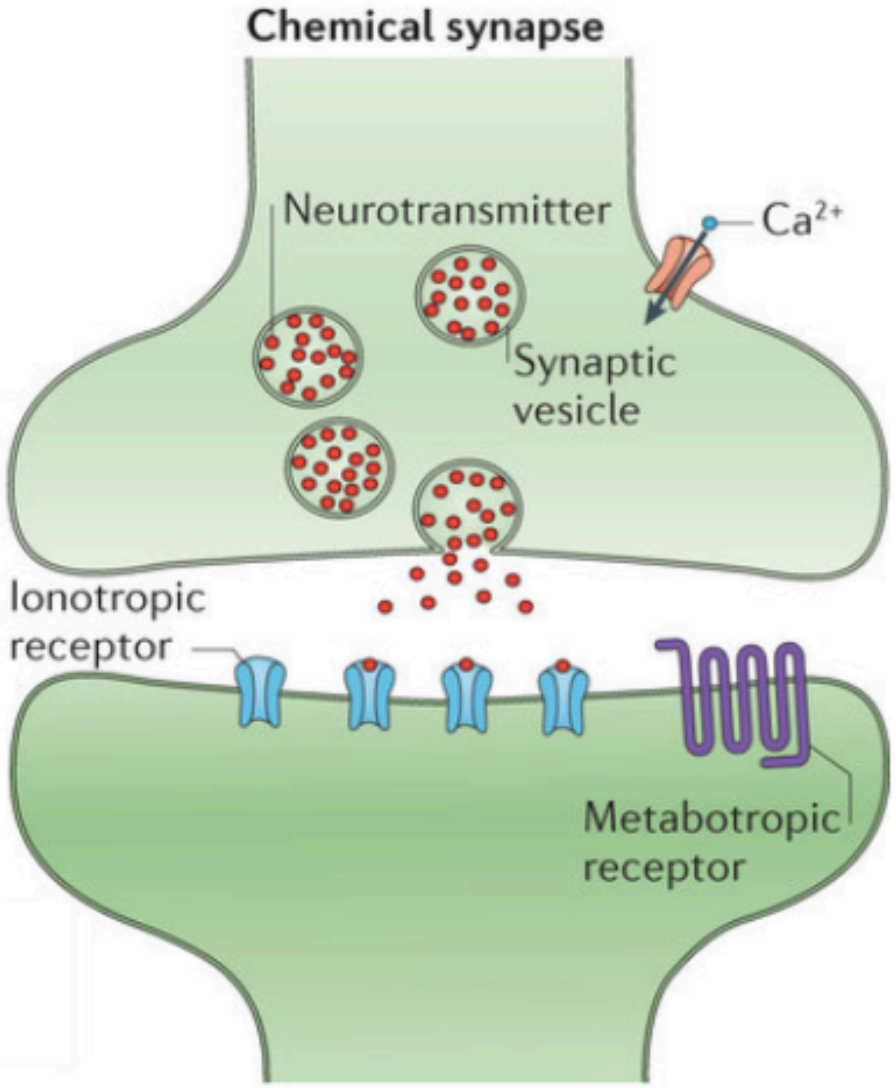


Saltatory Conduction

- In myelinated axons



Chemical Synapse



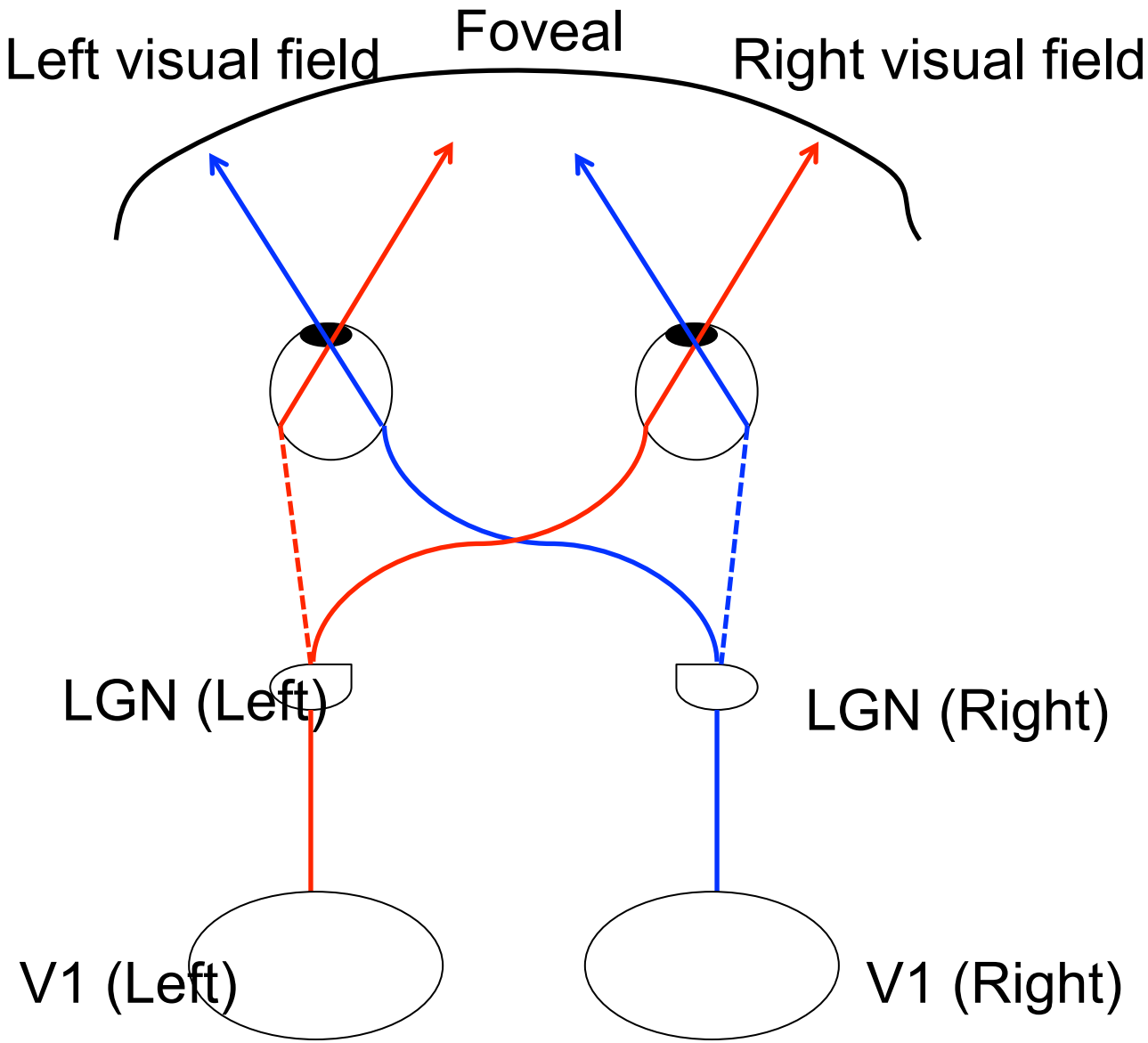
Presynaptic Terminal

Postsynaptic Terminal

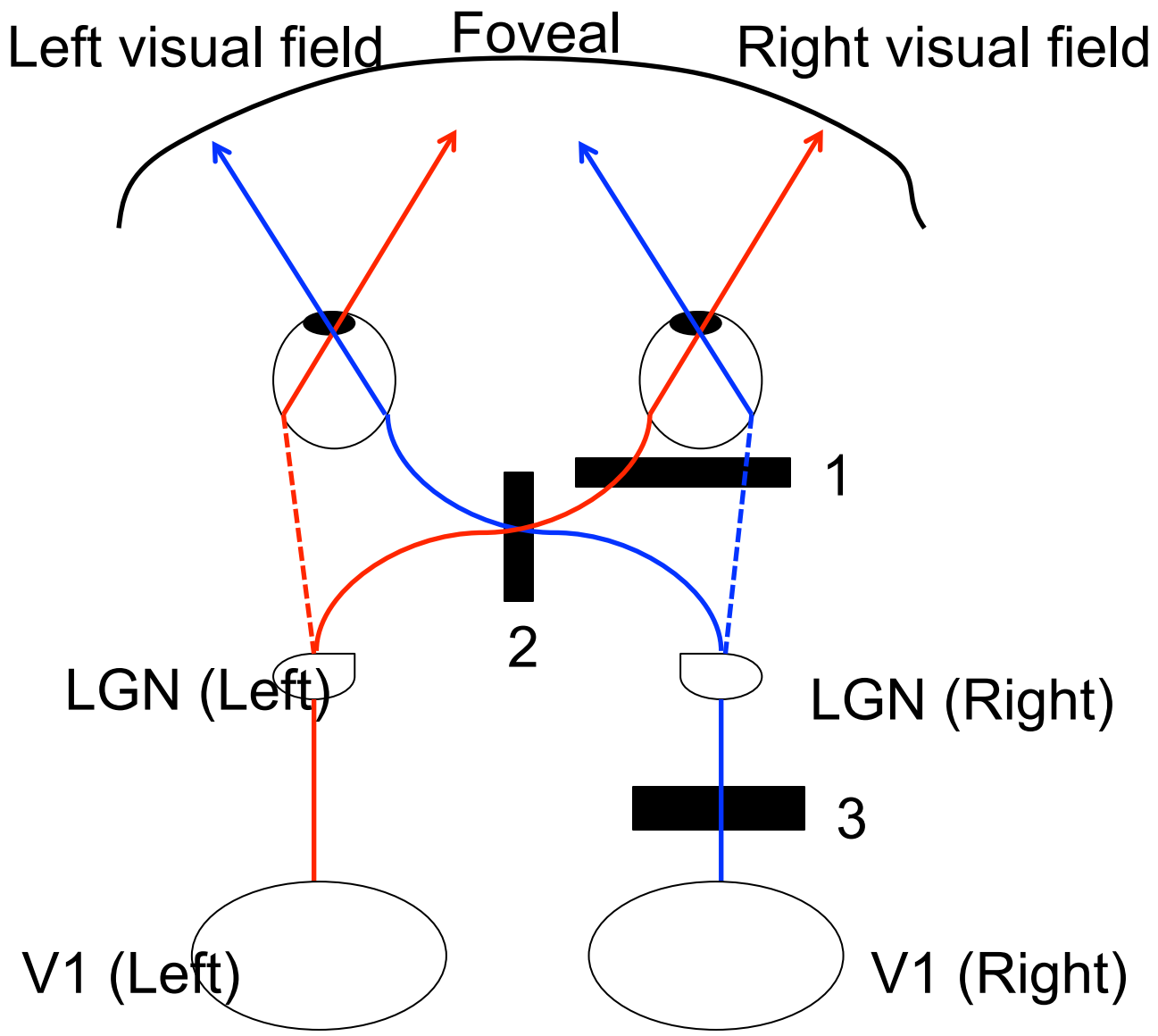
Essentials: Vision

- Vision
  - Visual hierarchy & pathway
  - what happens with damages to different parts of visual pathway.
- Vision ≠ Camcorder: Flexible mapping between external world and perception
  - Functional overrepresentation
  - Cortical plasticity
  - Perceptual filling-in

Visual pathway

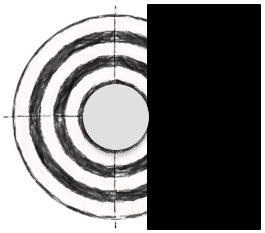


Visual pathway lesions

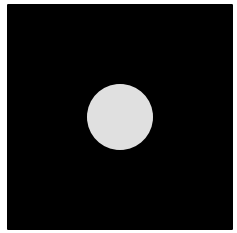


Visual field

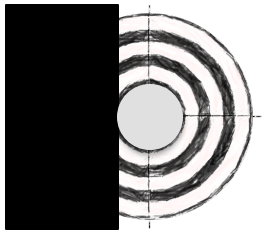
1



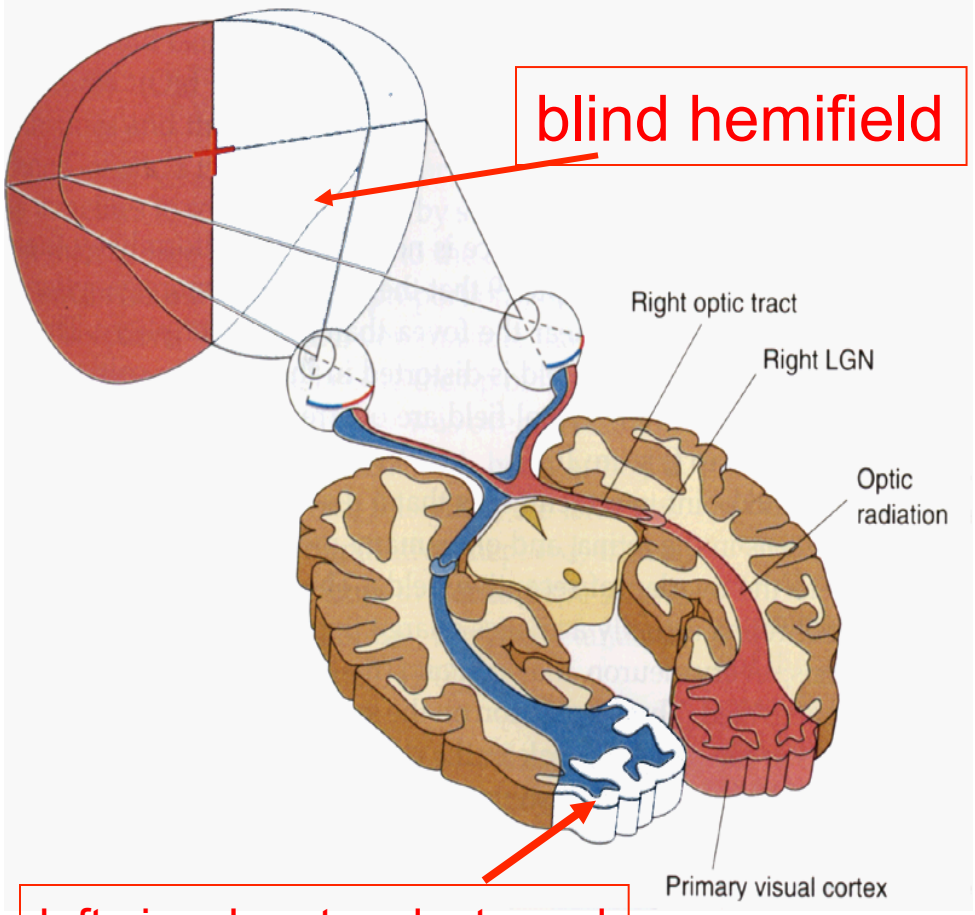
2



3



Blindsight: some perception in "blind" parts of visual field



Patient fixates cross and test for function in the blind hemi-field (make them guess)

In the blind field, patients can identify stimulus properties

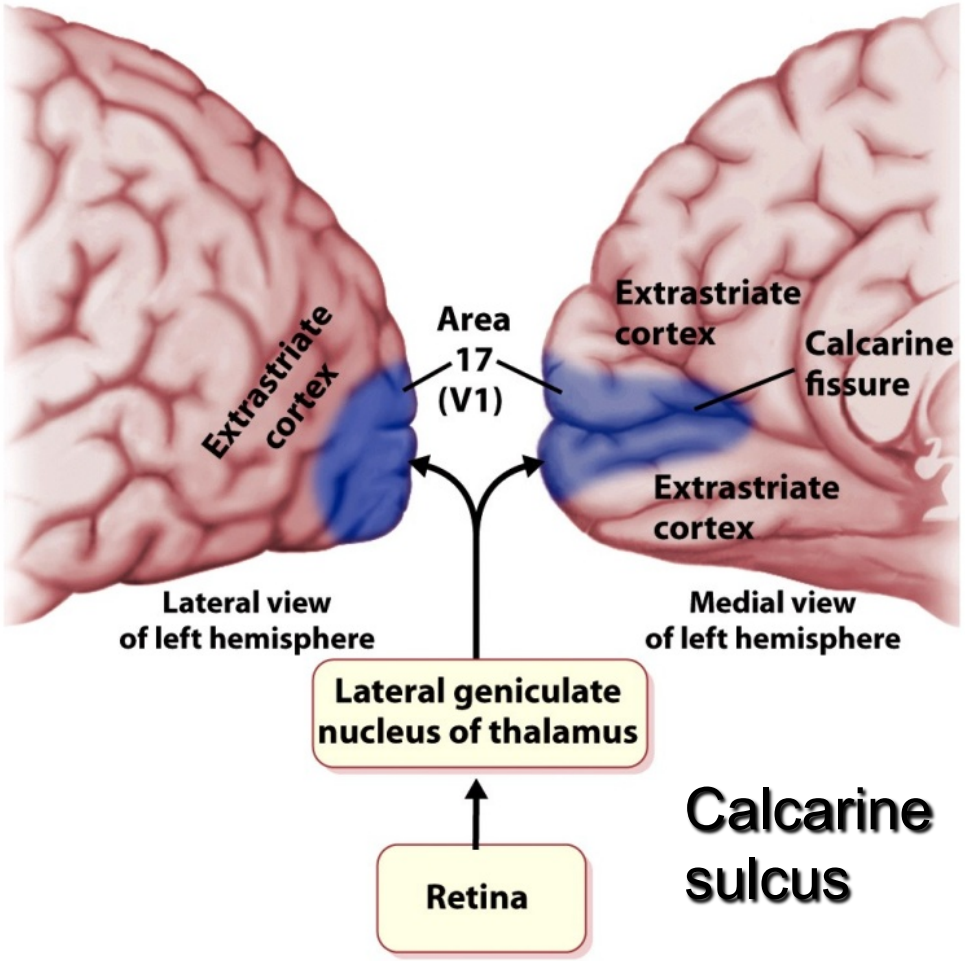
- direction of motion
- size
- line orientation
- simple shapes

How does this happen?

- Subcortical pathways
- residual V1 function

Weiskrantz

Next stop: Primary Visual Cortex, V1 (Brodmann area 17)



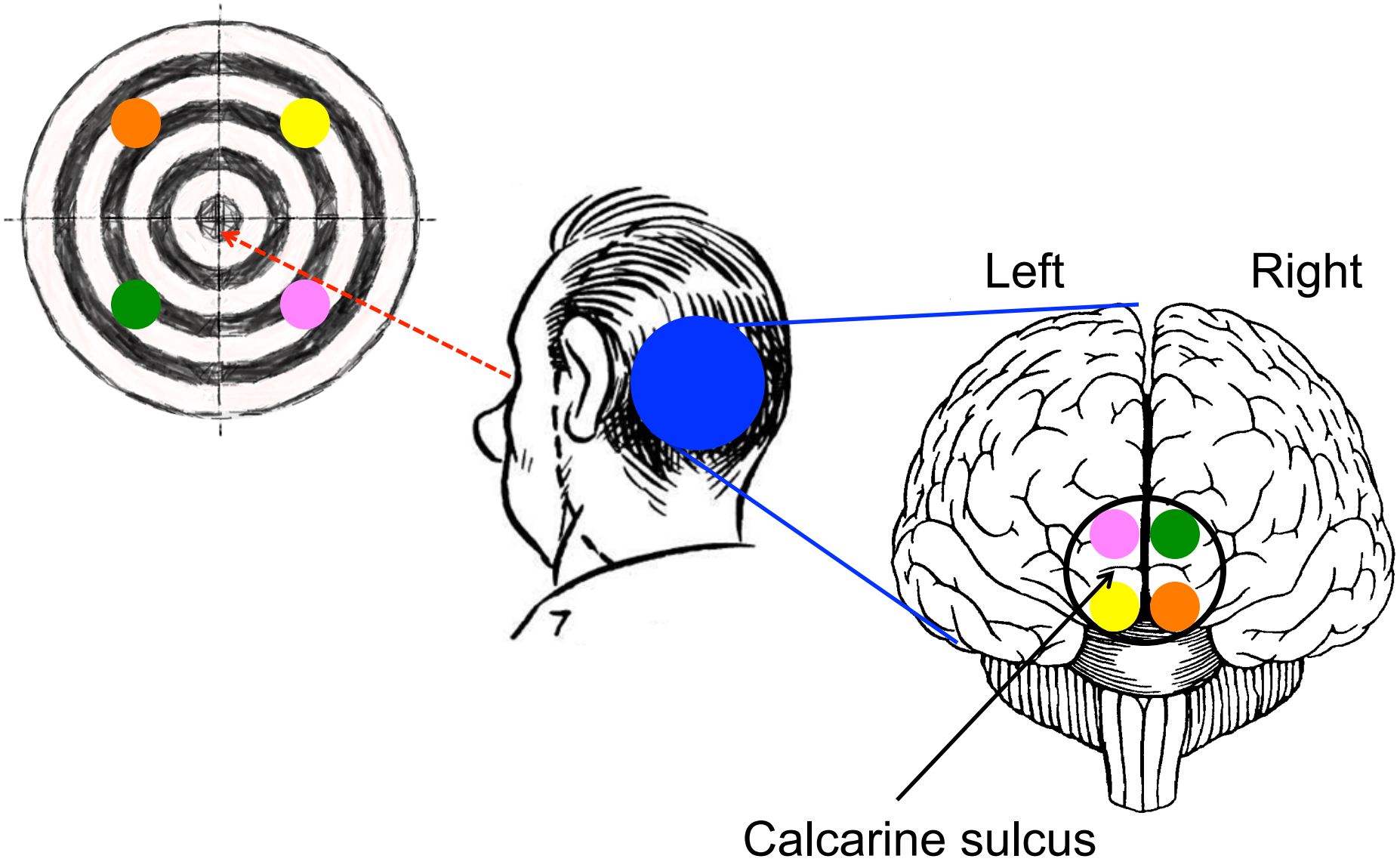
- Upper visual field = inferior to calcarine
- Lower visual field = superior to calcarine

e.g., visual world is flipped in cortex

Calcarine sulcus divides upper + lower hemifields.

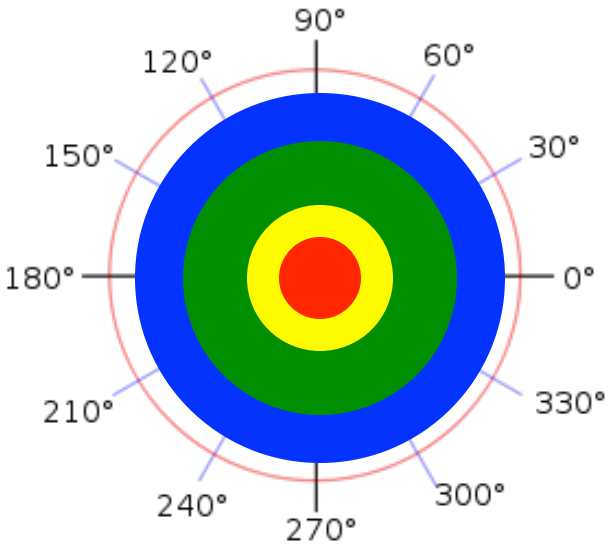
http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/what-where/what-where.html

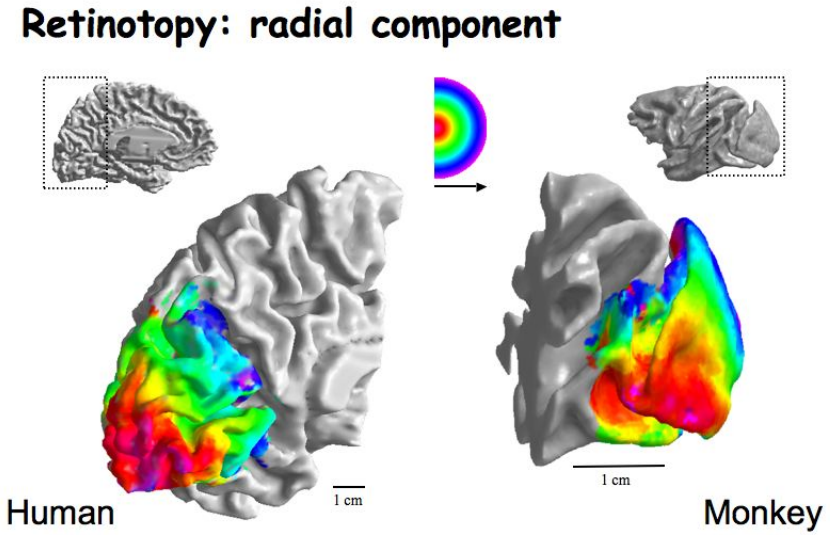
Visual field and visual cortex



Organization of visual cortex

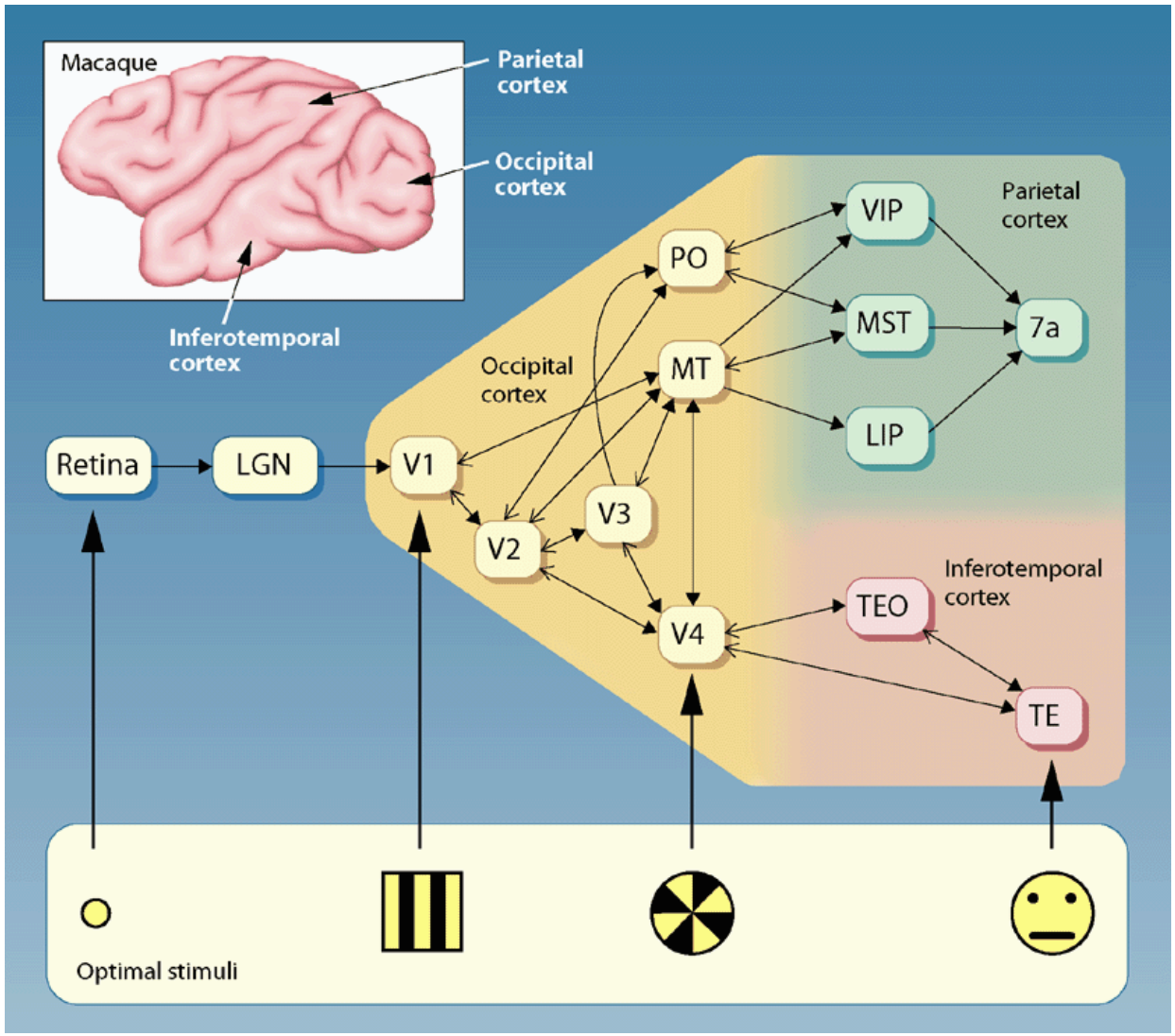
- topography of the visual world is preserved in V1~v4





http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/what-where/what-where.html

Next stop: V4, MT

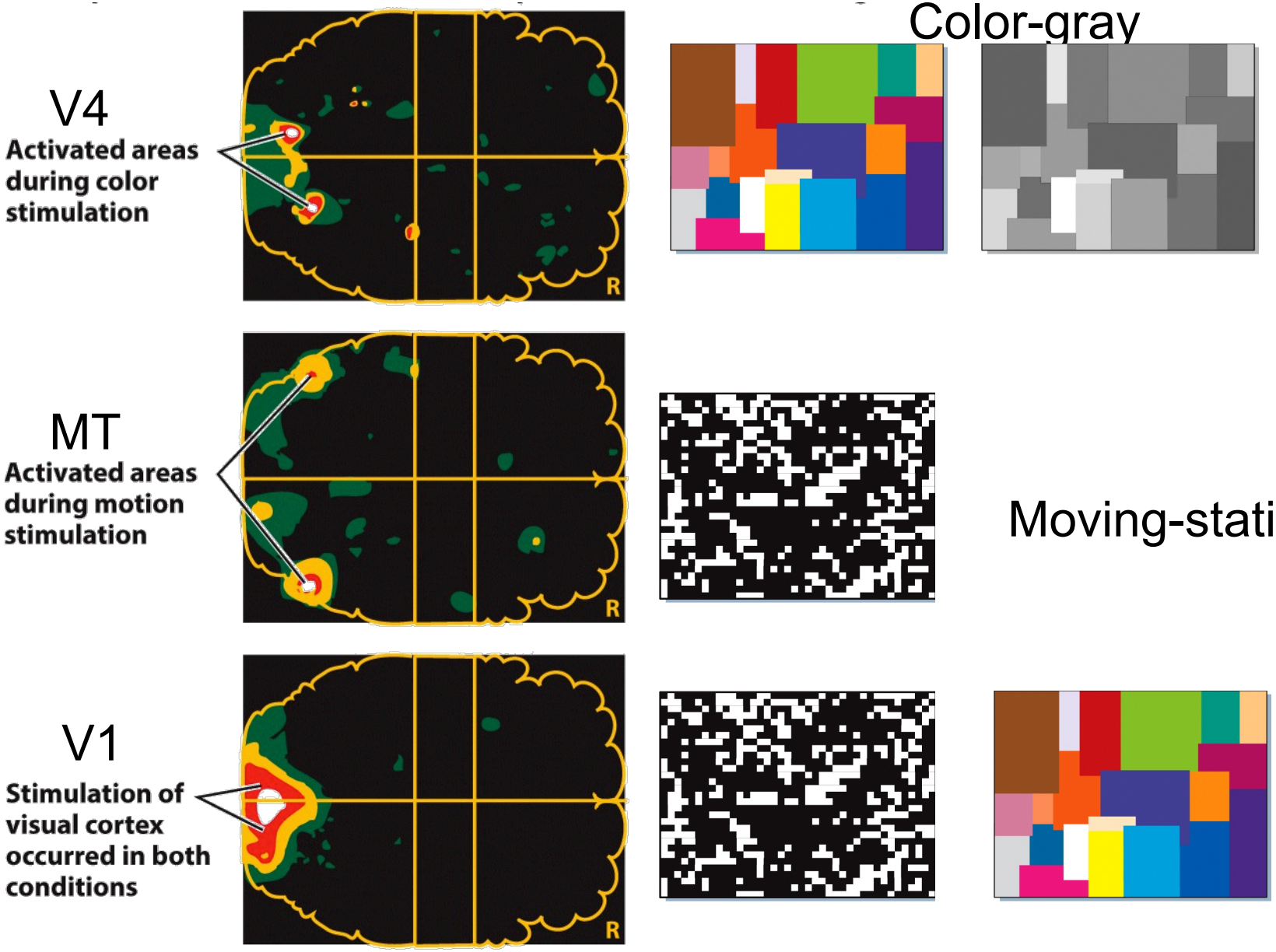


Dorsal pathway

Ventral pathway

Van Essen and DeYoe 1995

Specialized feature processing in the human brain

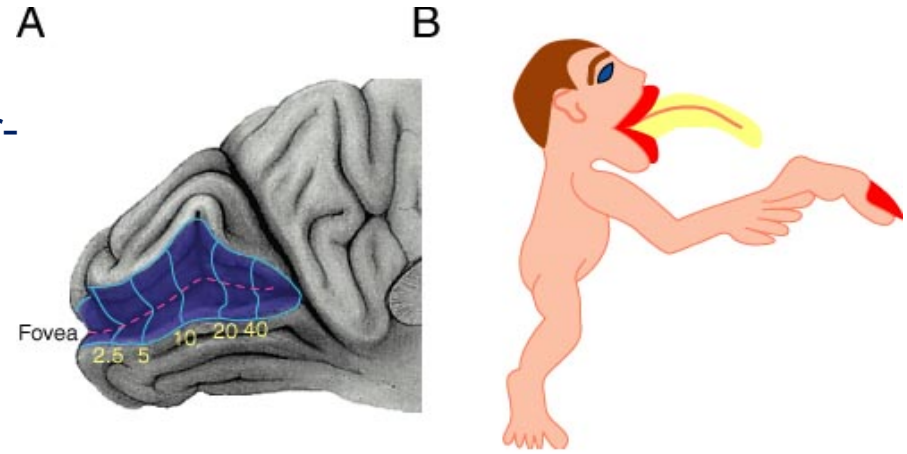


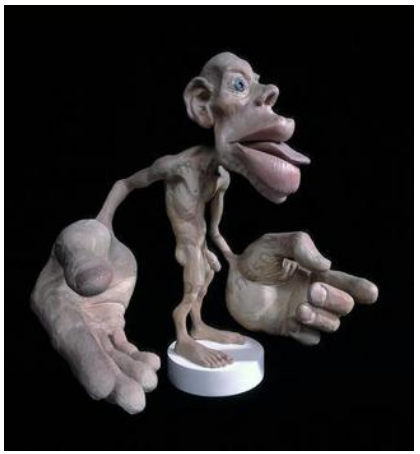
Zeki, S., 1993.

Perception is not a faithful replication of stimuli in the environment

- Perceptions are constructions by our CNS and reflect the behavioral function of sensory information.

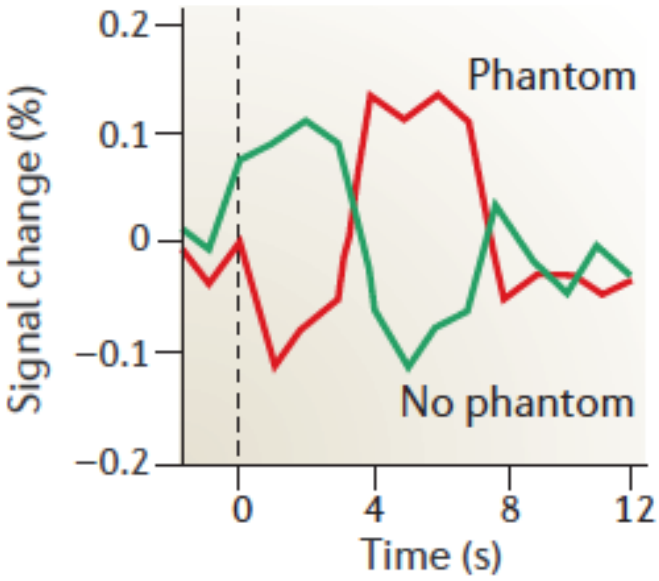
Visual system: over-representation of central vision.

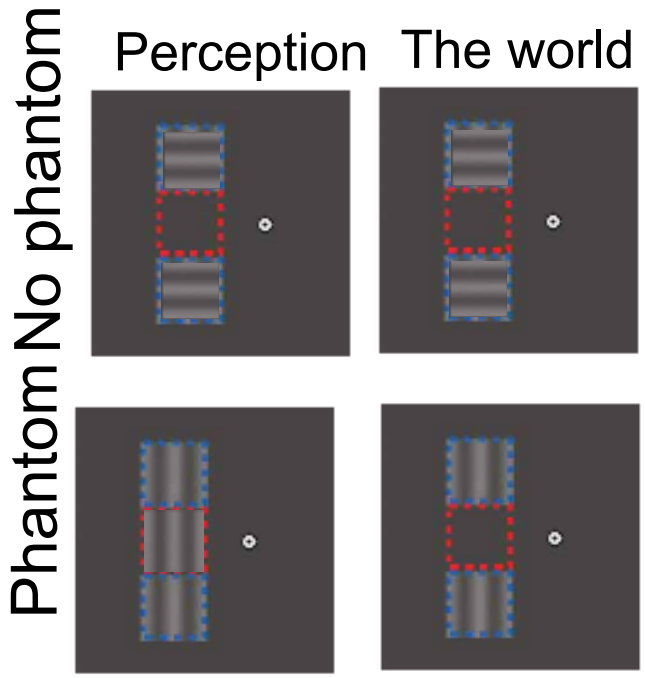


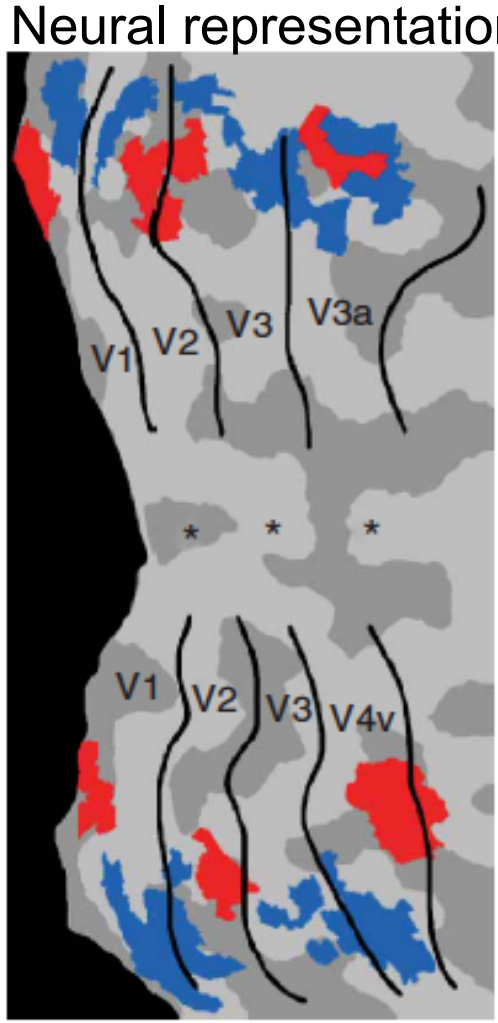


Somatosensory system: over-representation of thumb, mouth, tongue .

Perceptual Filling-in: Reconstructive

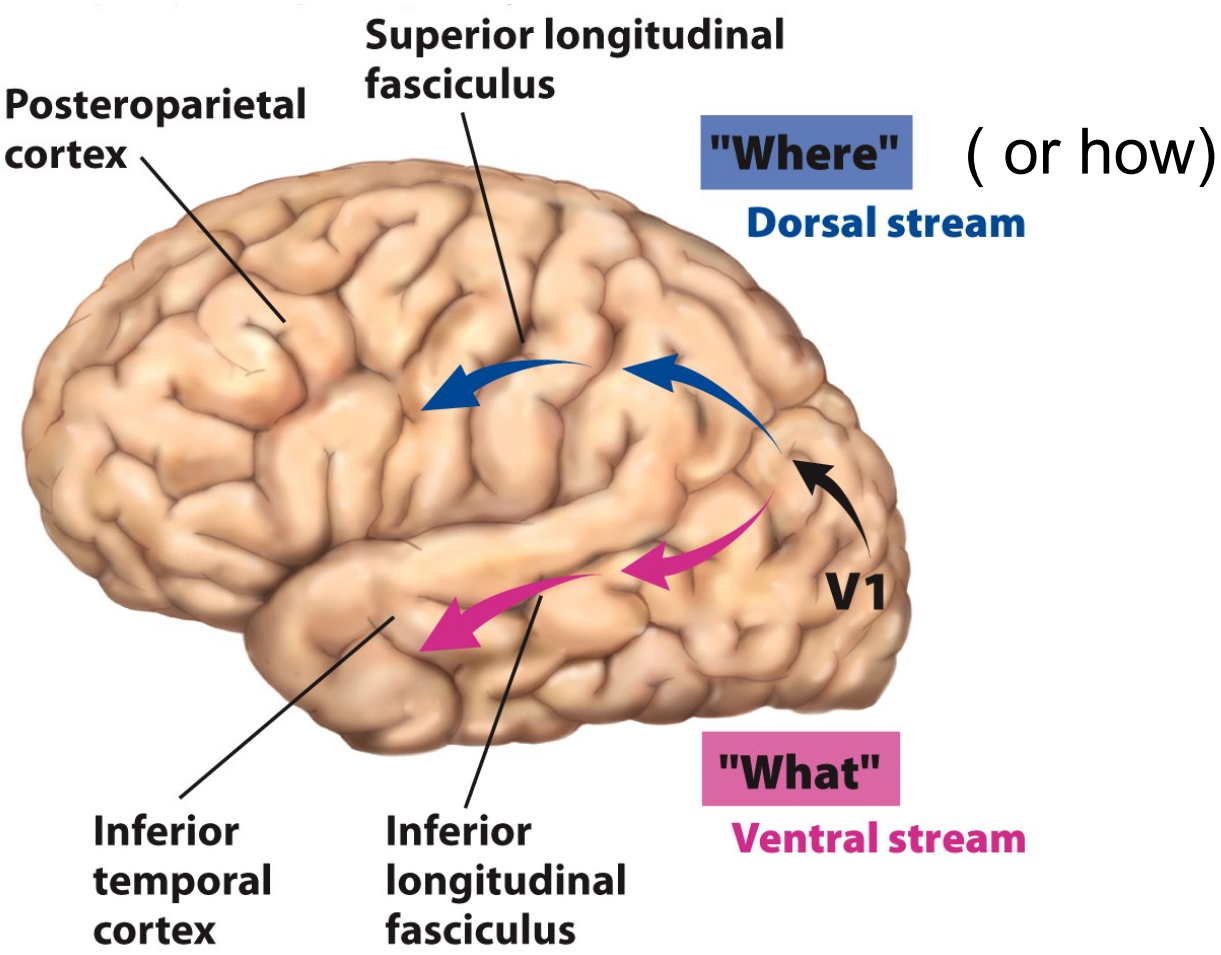




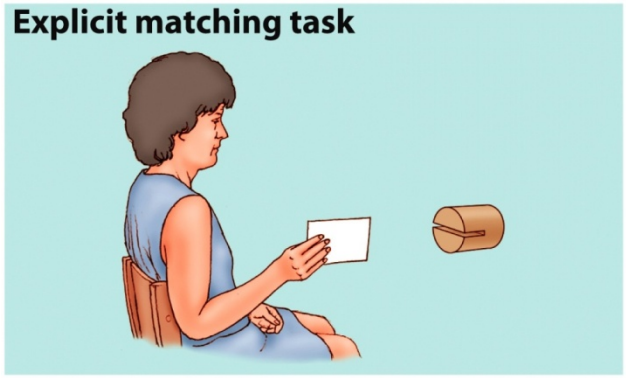


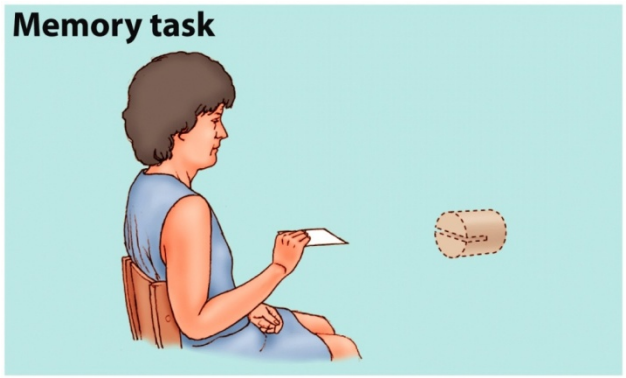
- The activity in the gap region (red square) increased after the phantom was perceived, and decreased when the phantom disappeared
- Providing the neural mechanisms of perceptual filling-in

Meng et al. (2005)


Superior longitudinal fasciculus
Posteroparietal cortex
"Where"
(or how)
Dorsal stream
V1
"What"
Ventral stream
Inferior temporal cortex
Inferior longitudinal fasciculus

Ventral “what” pathway lesion





- Bilateral LOC damage
- cannot recognize objects
  - can’t tell the orientation of the slot
- but knows *“how”* to act on them (or spatial location)
  - post a letter into it
  - also intact memory for action
  - Dorsal ‘where or how’

Sufficient versus necessary

- Necessary– if you damage it, that function goes away
  - Damage LOC, see object recognition damage
  - Same with Temporal lobe
- Sufficient – you only need one region for the function
  - Impossible to prove with neuropsych

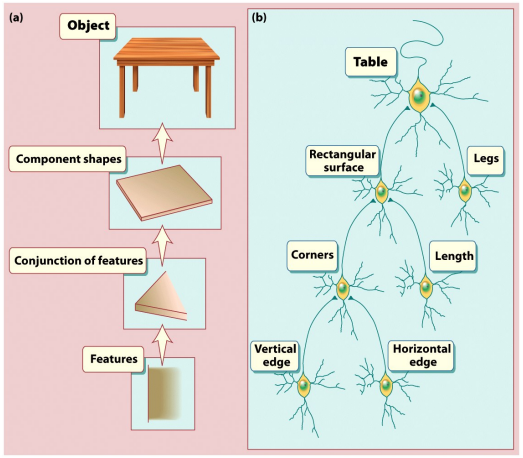
Grandmother versus Ensemble

Grandmother cell

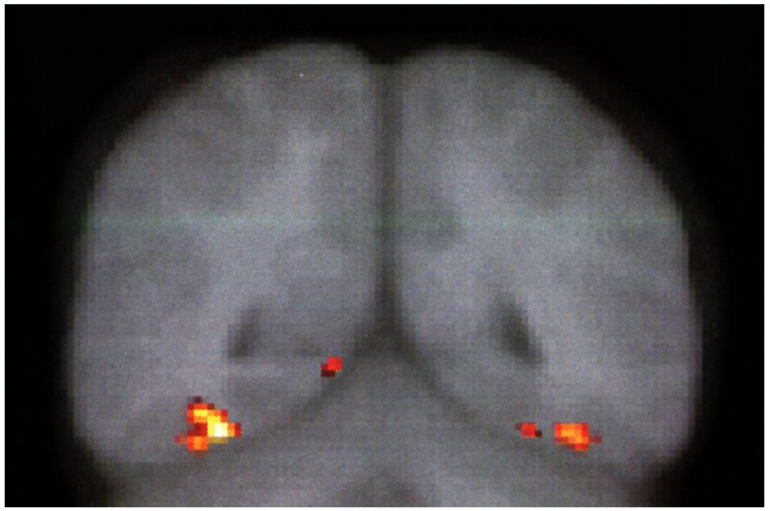
- One cell needed for every angle of your grandmother
- If lost, you can no longer perceive grandmother from that angle

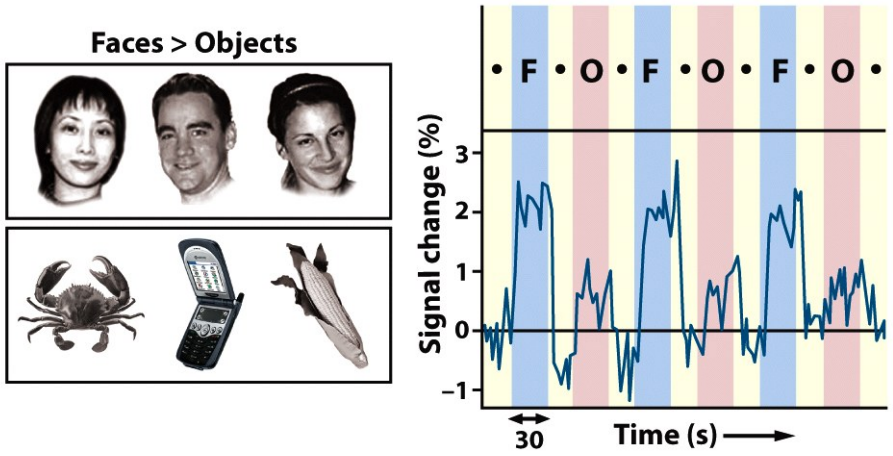
Ensemble

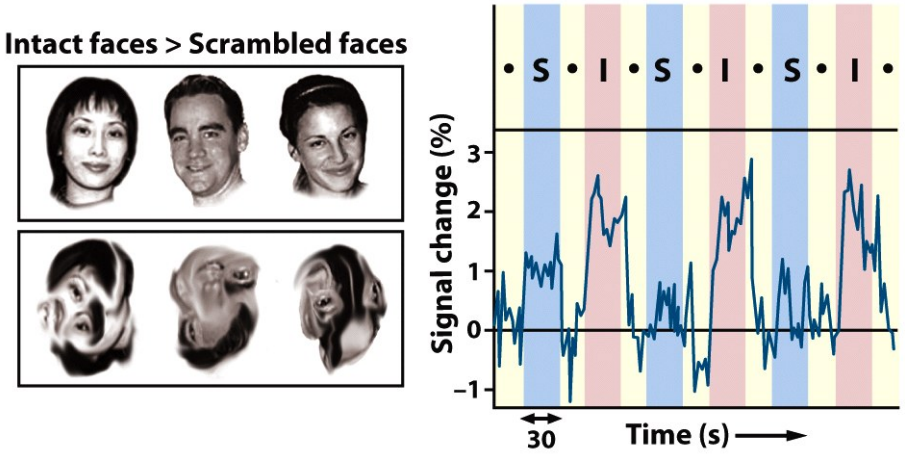
- Many neurons contribute to the cell (different attributes)
- If you loose one of them, you can still perceive your grandmother



Fusiform Gyrus

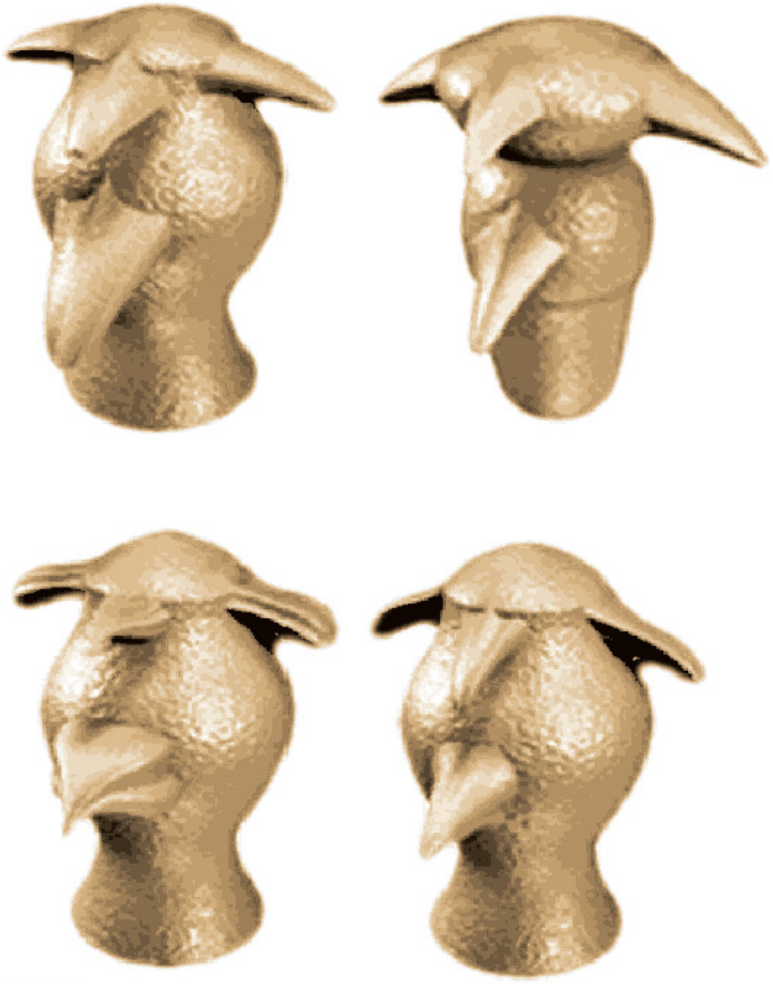




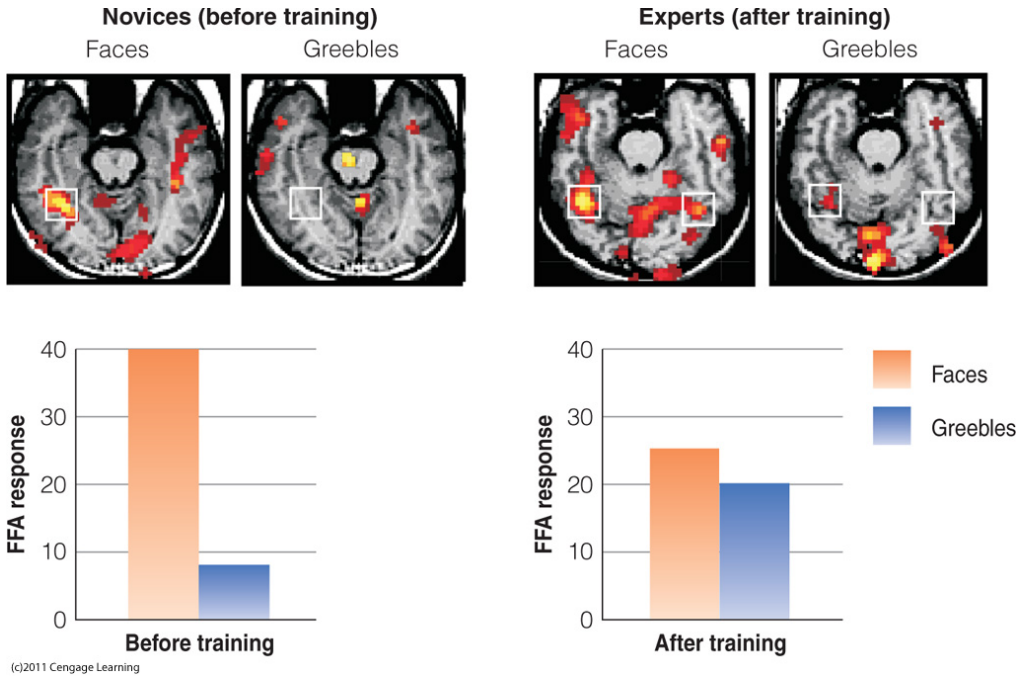


Why using scrambled face?

Expertise, yes!



Greeble stimuli used by Gauthier. Participants were trained to name each different Greeble.



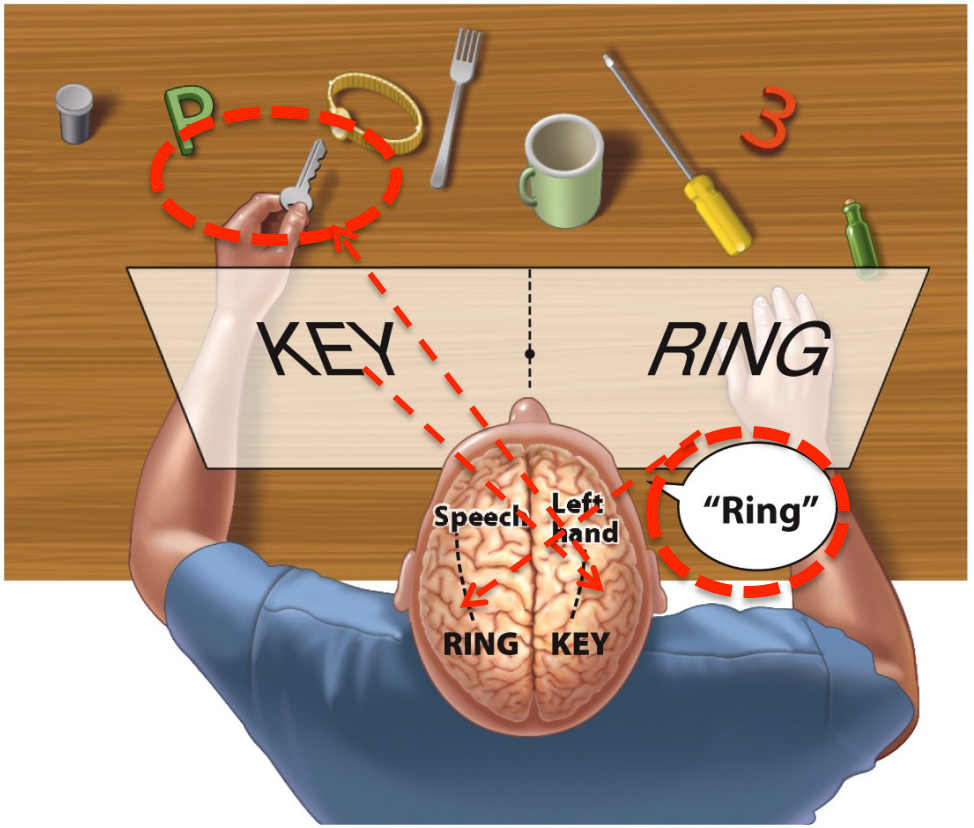
Magnitude of brain responses to faces and Greebles (a) before and (b) after Greeble training. The colored areas in the brain records indicate brain activity. The FFA is located within the white squares.

Training modulates FFA activities

Language in LH

Exp'ter: What did you see on the screen?
JW: Ring
Exp'ter: Anything else?
JW: Nothing
Exp'ter: Pick up the object with your left hand
JW picks up the key

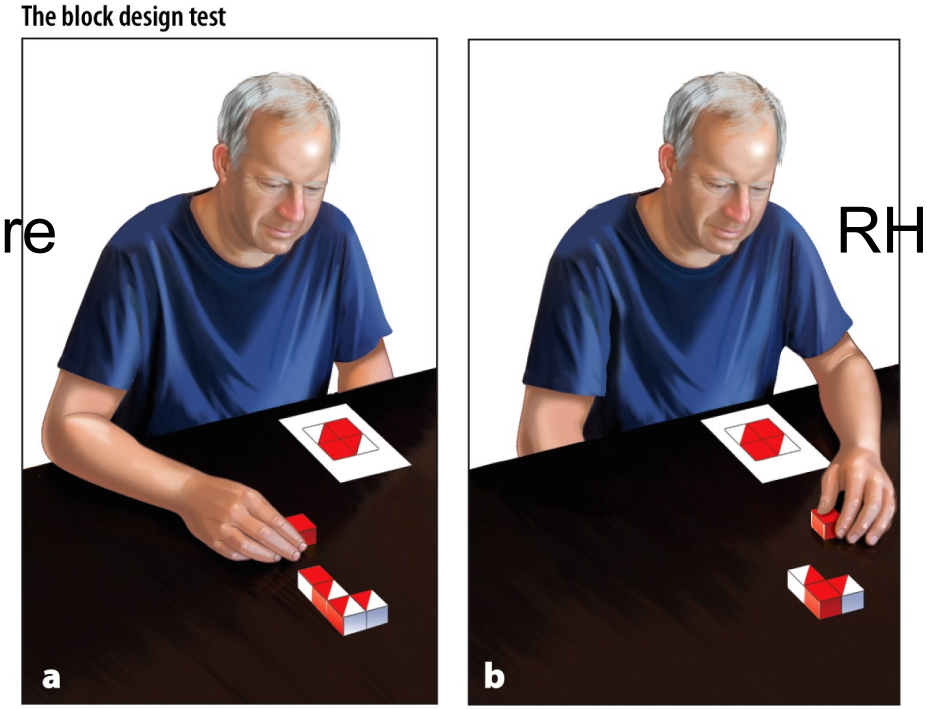
Only the LH can *produce* speech, but the RH has some basic language *comprehension*



Spatial Task in RH

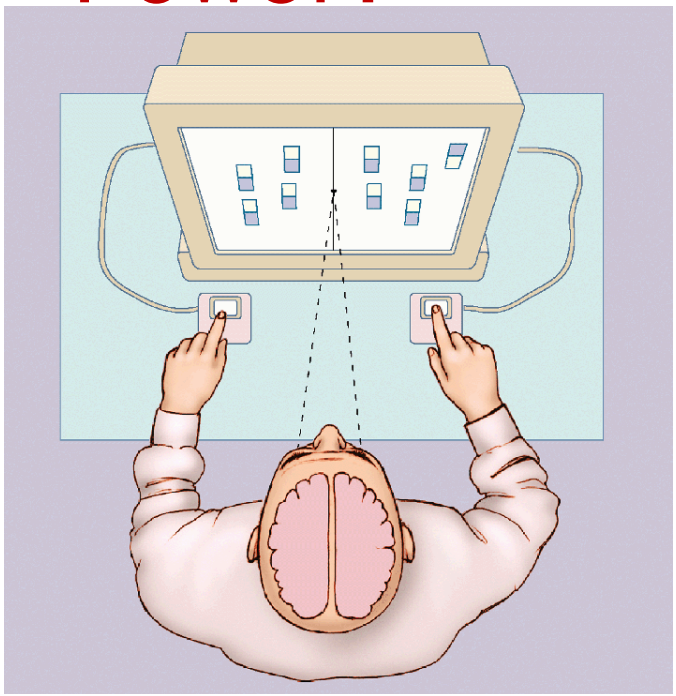
- Coordination of motor plans disrupted in split-brain patient, resulting in competition.
- The spatial figure construction task
  - is perfect with his left hand (right hemisphere, RH, wins)
  - but fails with his right hand (left hemisphere, LH, wins, thus inhibiting the RH)

LH: left hemisphere
Right hand



RH: right hemisphere
left hand

Split-brain Patients: Double the Mind Power?

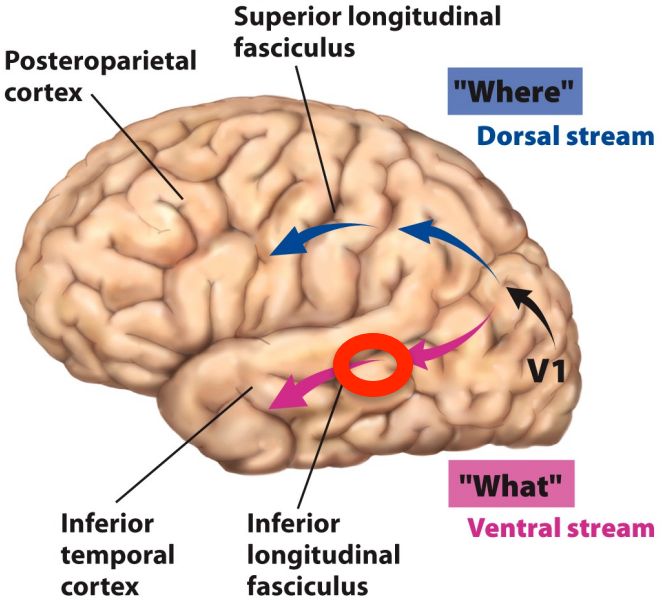


- TASK: search for combination of two features
- Split-brain patients perform visual search tasks twice as fast as normal participants
- Suggests that each hemisphere has its own mind

Luck, Hillyard, Mangun and Gazzaniga, *Nature*, 1989

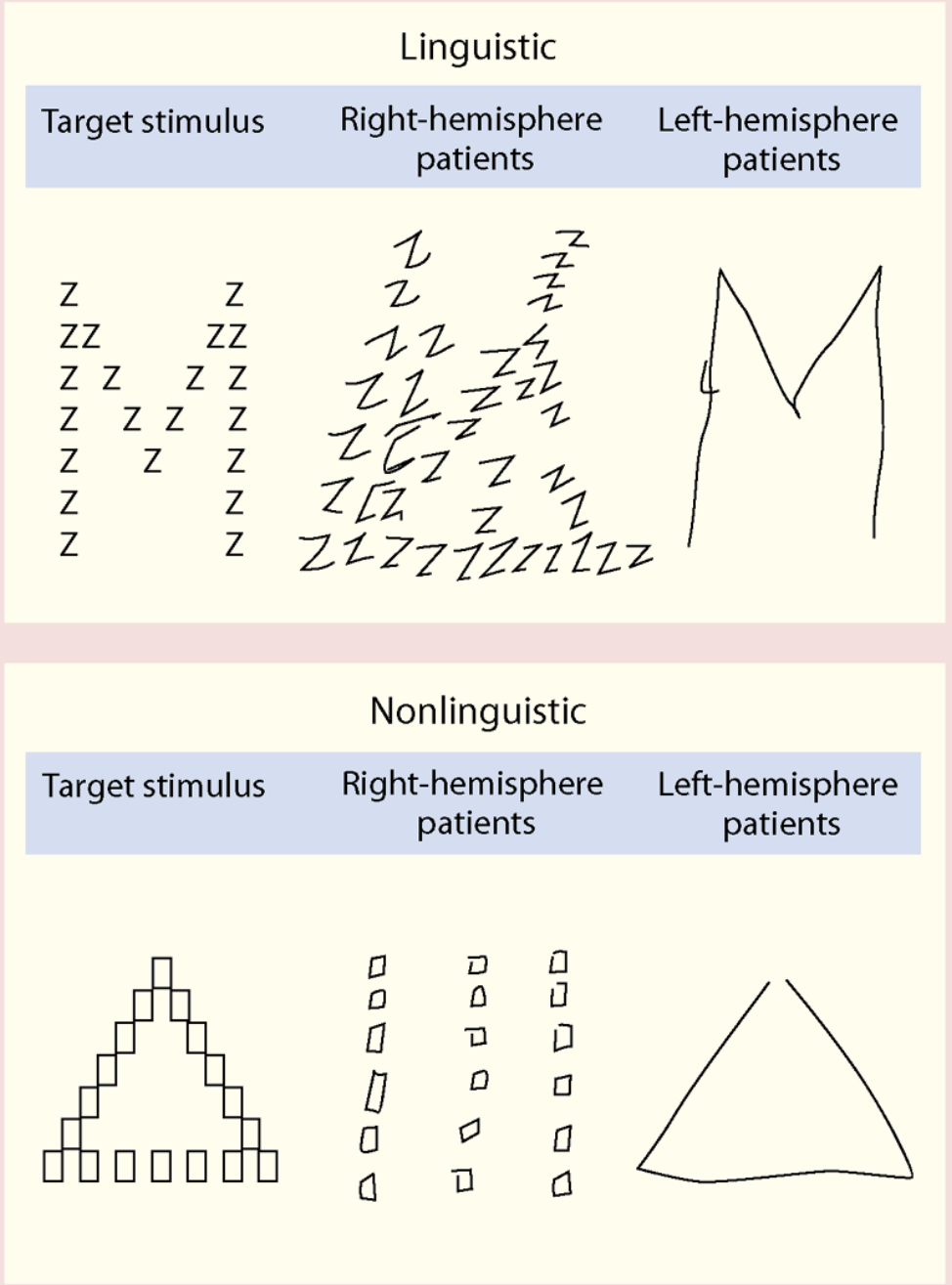
Local vs global processing

Unilateral lesions of temporo-parietal junction



LH patients: impaired at local processing

RH patients: impaired at global processing



Adapted from Delis, D., Robertson, L., and Efron, R., Hemispheric specialization of memory for visual hierarchical stimuli, Neuropsychologia 24 (1986): 205–21

Ventral pathway: Spatial frequency hypothesis

- LH - better at processing high spatial frequency information
  - Allows perception of details/edges (local)
- RH - better at processing low spatial frequency information
  - Allows perception of whole/overall shape (global)

Intact LSF+HSF

=

LSF (blob)

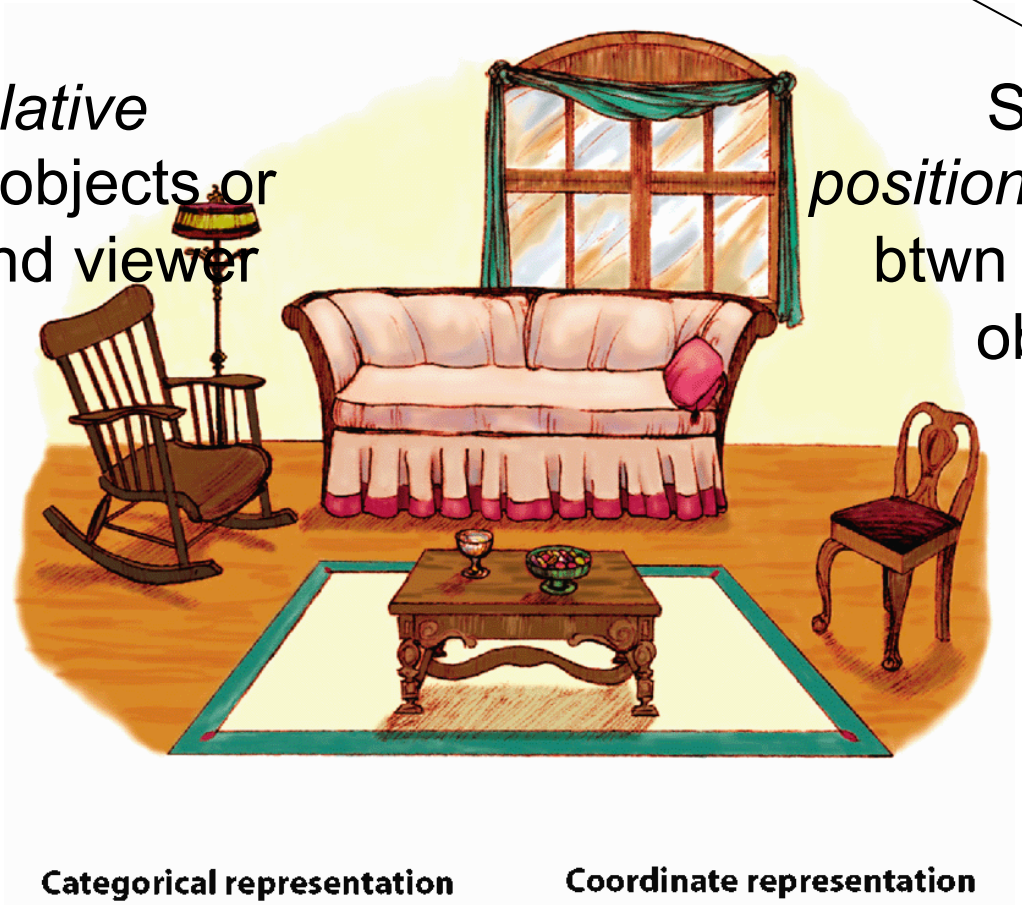
+

HSF (edge)

Categorical vs Coordinate Reps

Specify the *relative position* btwn objects or btwn object and viewer

Specify the *exact positions and distances* btwn objects or btwn object and viewer



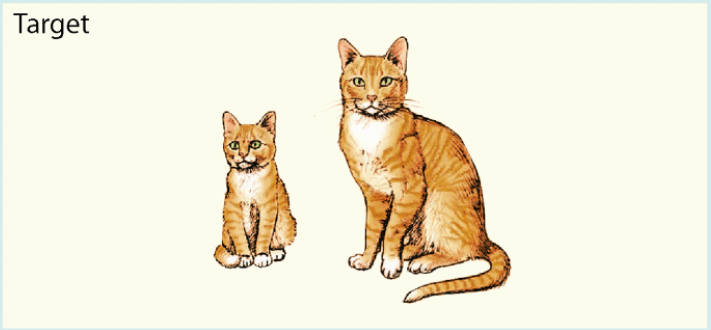
Categorical representation

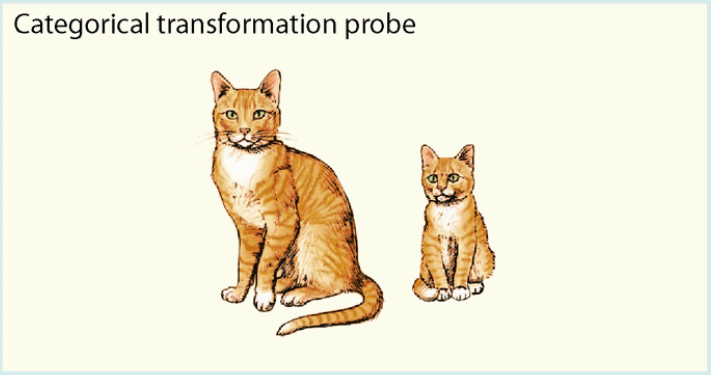
Rocking chair <u>left of</u> couch
Dining chair <u>right of</u> couch

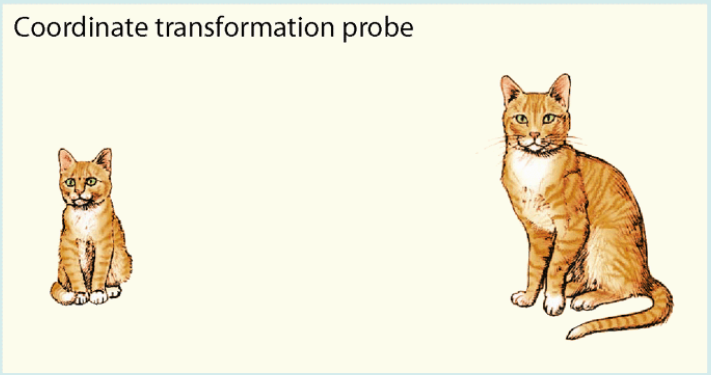
Coordinate representation

Rocking chair <u>2 feet from</u> couc
Rocking chair <u>closer than</u> dining chair to couch

Categorical (LH) vs Coordinate (RH) Reps







TASK: delayed match to sample

Patients with LH lesions worse on categorical mismatches

Patients with RH lesions worse on coordinate mismatches

Kosslyn et al. 94

Hemispheric Specialization Essentials

- Language
  - RH – language comprehension only
  - LH – both language production and comprehension
- Visuo-spatial
  - RH – intact
  - LH – impaired
- Ventral pathway
  - RH – global and low spatial frequency
  - LH – local and high spatial frequency
- Dorsal pathway
  - RH – coordinate (distance)
  - LH – categorical (relative position)

What is attention?

- *William James* – taking possession of the mind, concentration of consciousness
- *Gottlieb* – improvement in the ability to discriminate detect or memorize attended object
- *Book* – mechanism that enables one to process relevant inputs, thoughts, or actions while ignoring others

- We have a *limited capacity* to process information.
- Therefore there is *competition* between items for processing.
- Attention is the mechanism that ***selects*** the most important/ behaviorally relevant information at the ***cost*** of others.

What is attention for?

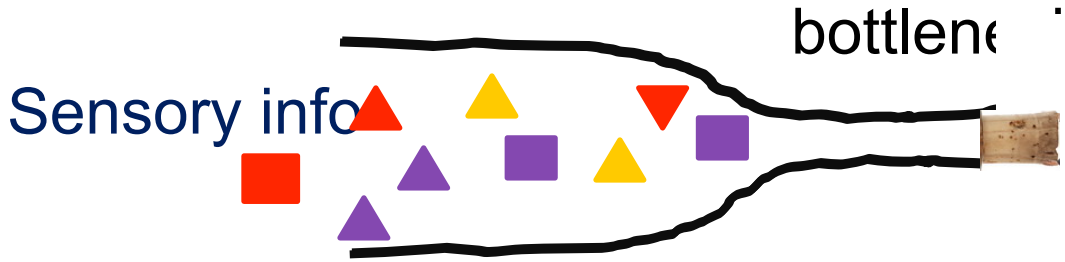
- We have limited capacity to process sensory information.
- Sensory overload

Dave Sullivan

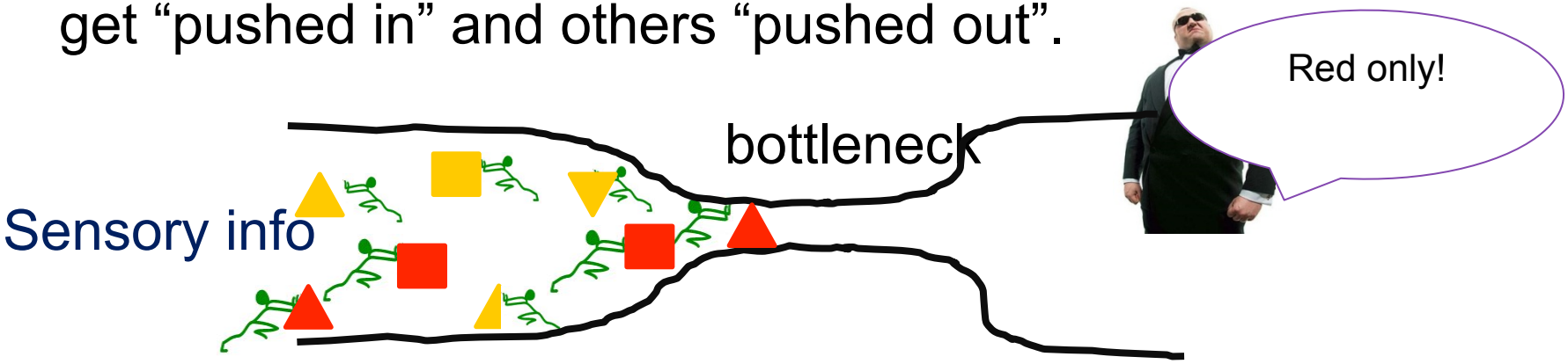
Two mechanisms of selection

- Voluntary attention : select information relevant to current goals and ignore irrelevant information (top-down).
  - Finding Waldo.
- Reflexive attention: re-orienting towards unexpected, but potentially important information.
  - Turning towards sound of sirens.
  - Flashy online ads

Limitations in processing can be described as a “bottleneck”

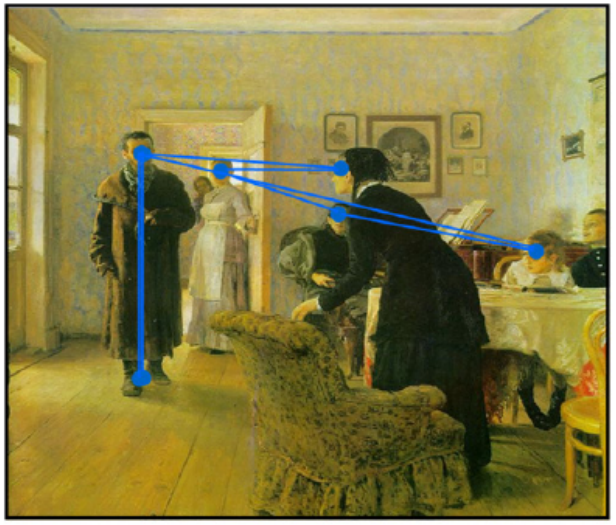


Attention is the process by which some things get “pushed in” and others “pushed out”.

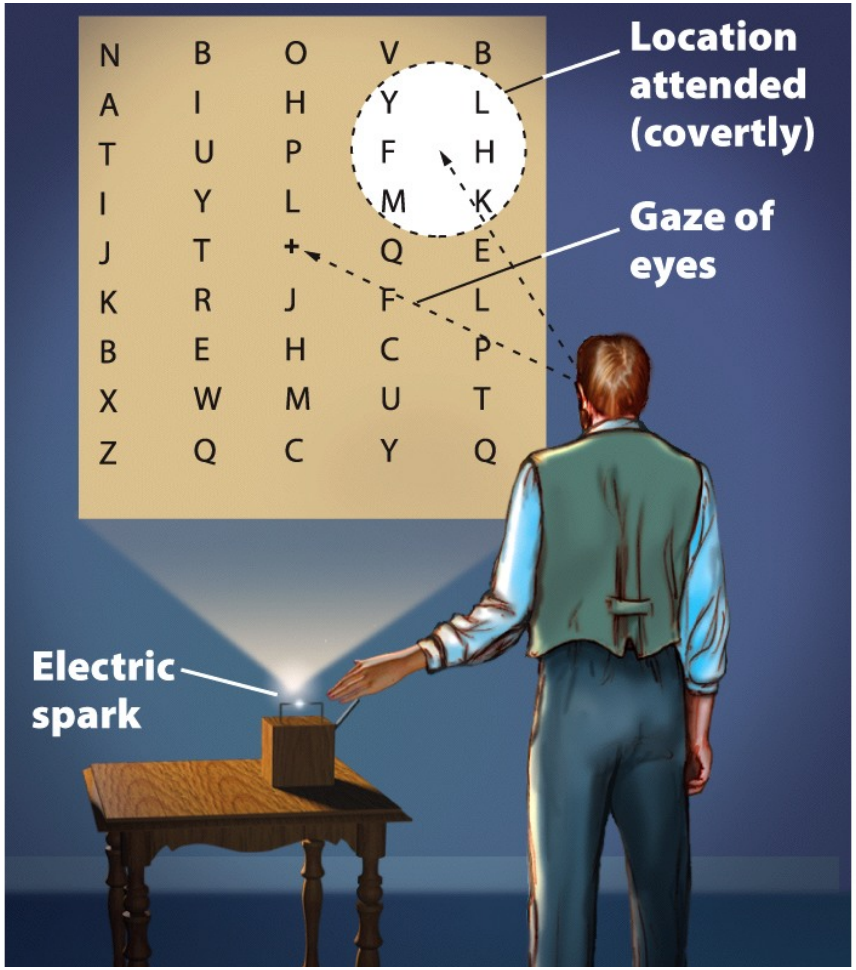


Eye Movements and Visual Attention

- We can see details only at the center of gaze
- We therefore make frequent eye movements to bring information into high resolution fovea and inspect objects of interest
  - Approximately 3 per second during scene viewing
  - This is called "overt" attention



Helmholtz's visual attention experiment




Hermann von Helmholtz (1821–1894)

Bettmann/Corbis

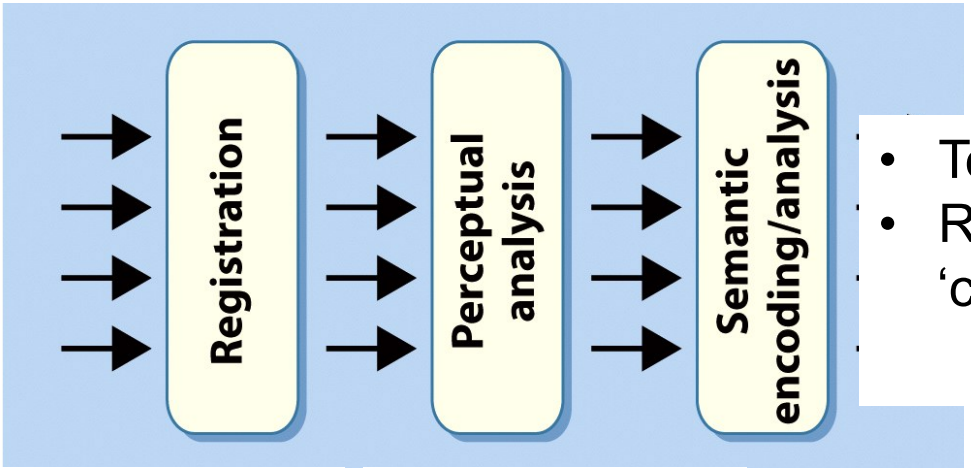
could covertly attend to any location on the screen and perceive the letters located within this region but had difficulty perceiving the letters at other locations.

Early vs. late selection

'Find the red 'Cat'

Cat
Dog
Dog
Mouse
Mouse
Cat
Dog
Mouse
Cat

Cat



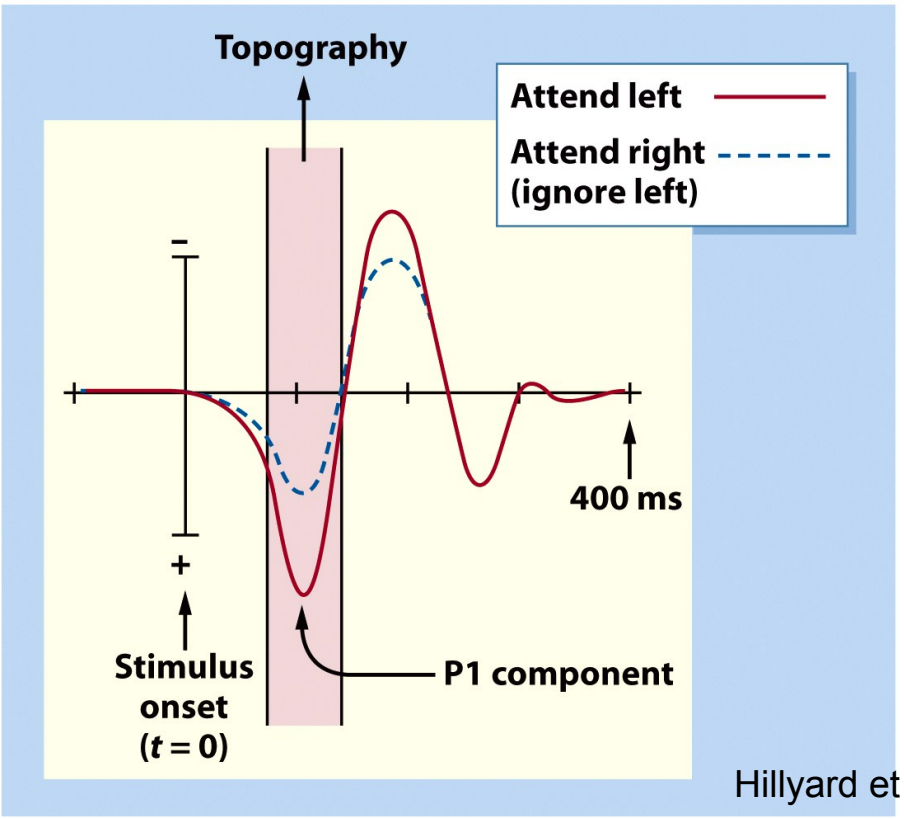
- Temporal lobe
- Recognize what 'cat' means

- Visual pathway
- Retina – V1
- Raw sensory info

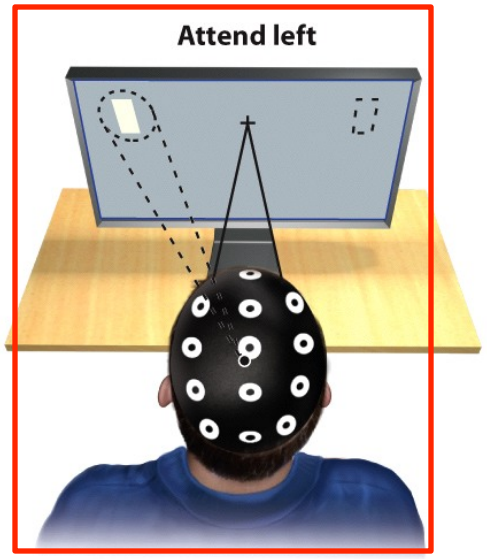
- V1-V4
- Feature info
- Red, lines

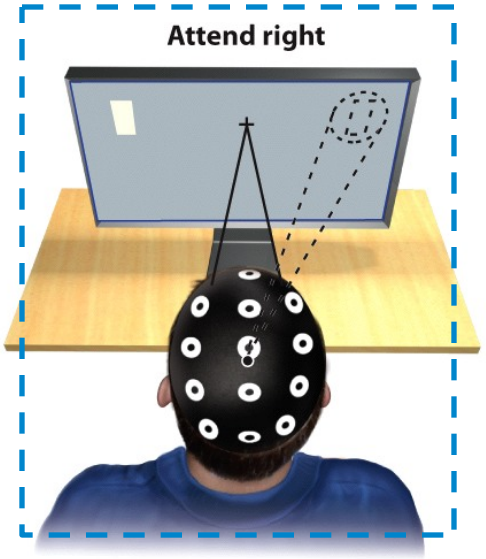
Early: select red and line shapes of the letters
Late: select 'Cat' by knowing it's meaning, and check if it's re

Early Selection & ERP



Hillyard et al.

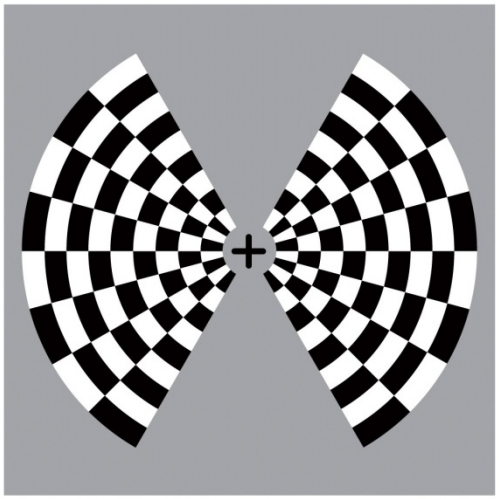




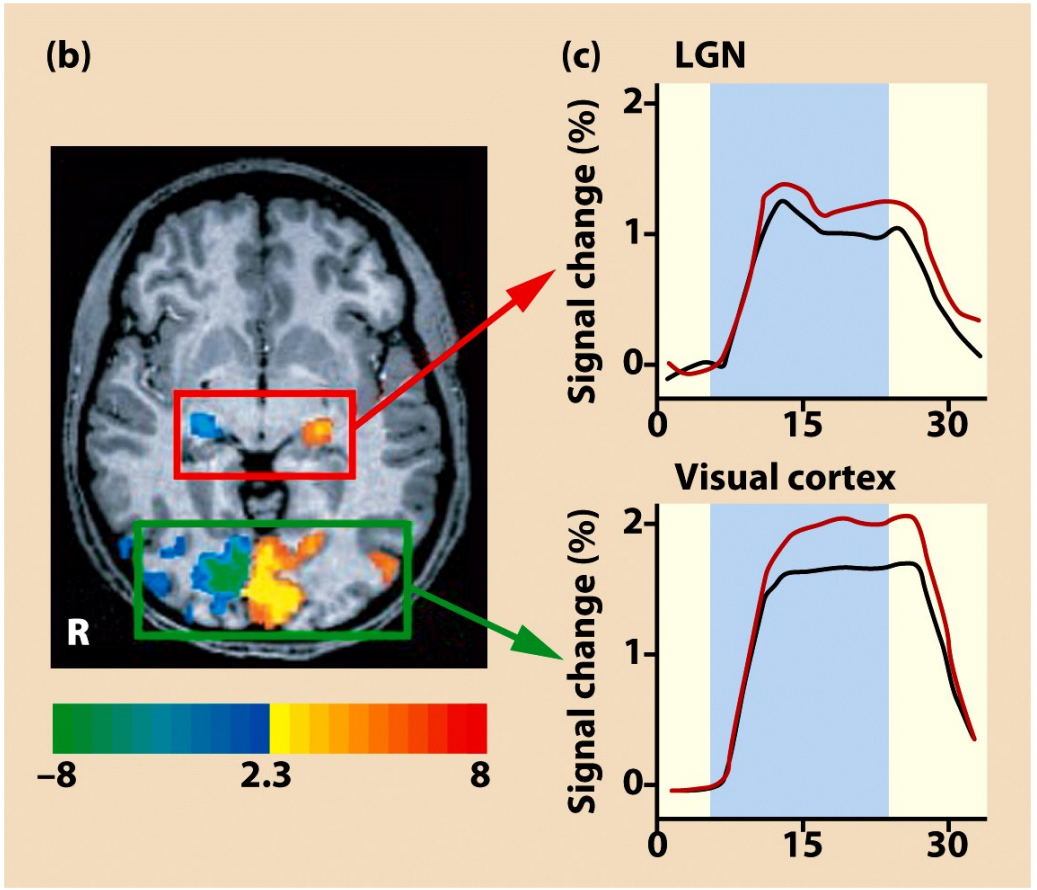
- P1 begins 70-90 ms after stimulus.
- Suggests attention amplifies perceived stimulus
- Similar findings in auditory attention (N1)

Electrode over right occipital cortex

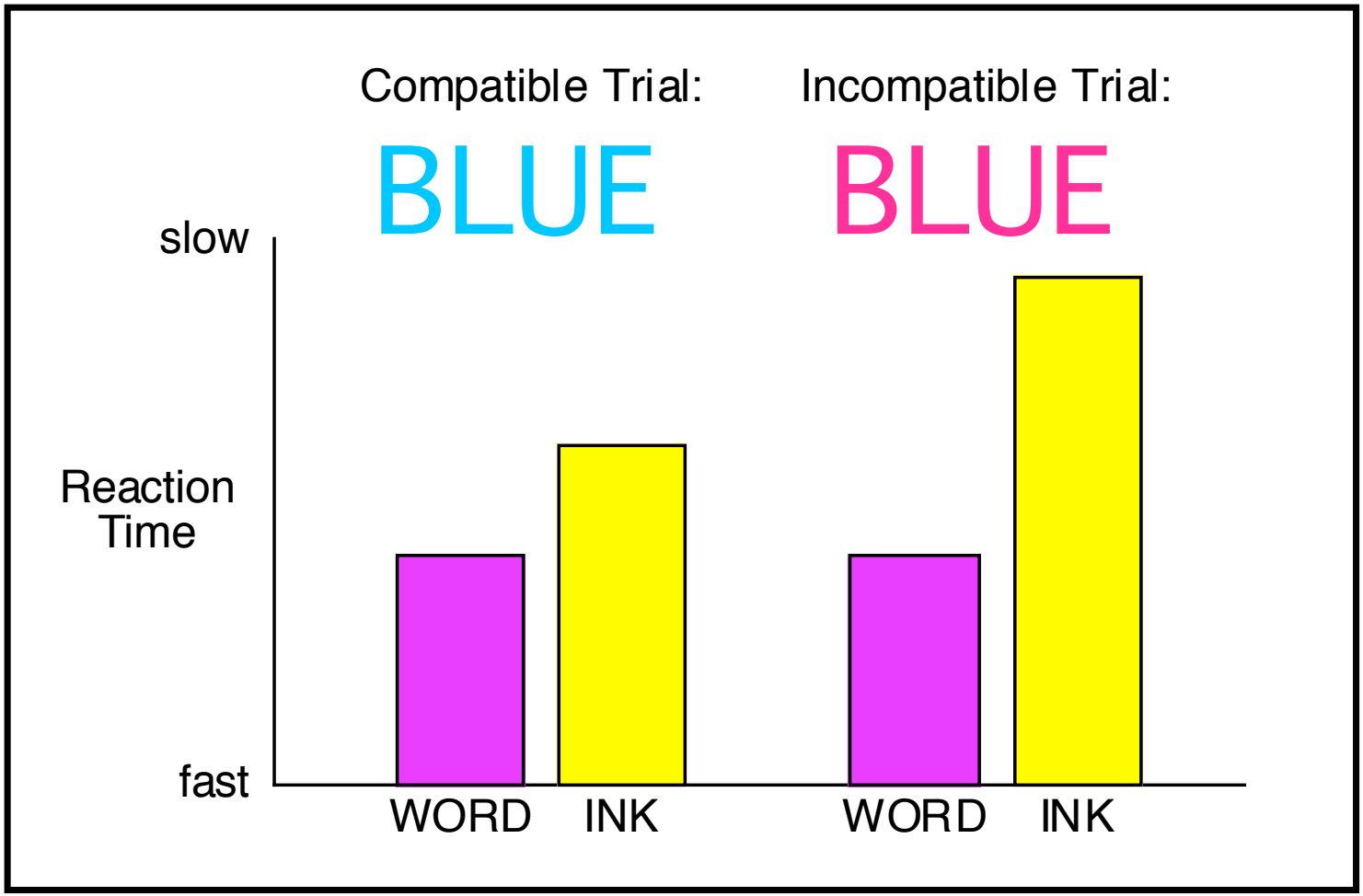
LGN modulated by spatial attention.



Attend to left or right and detect luminance change.

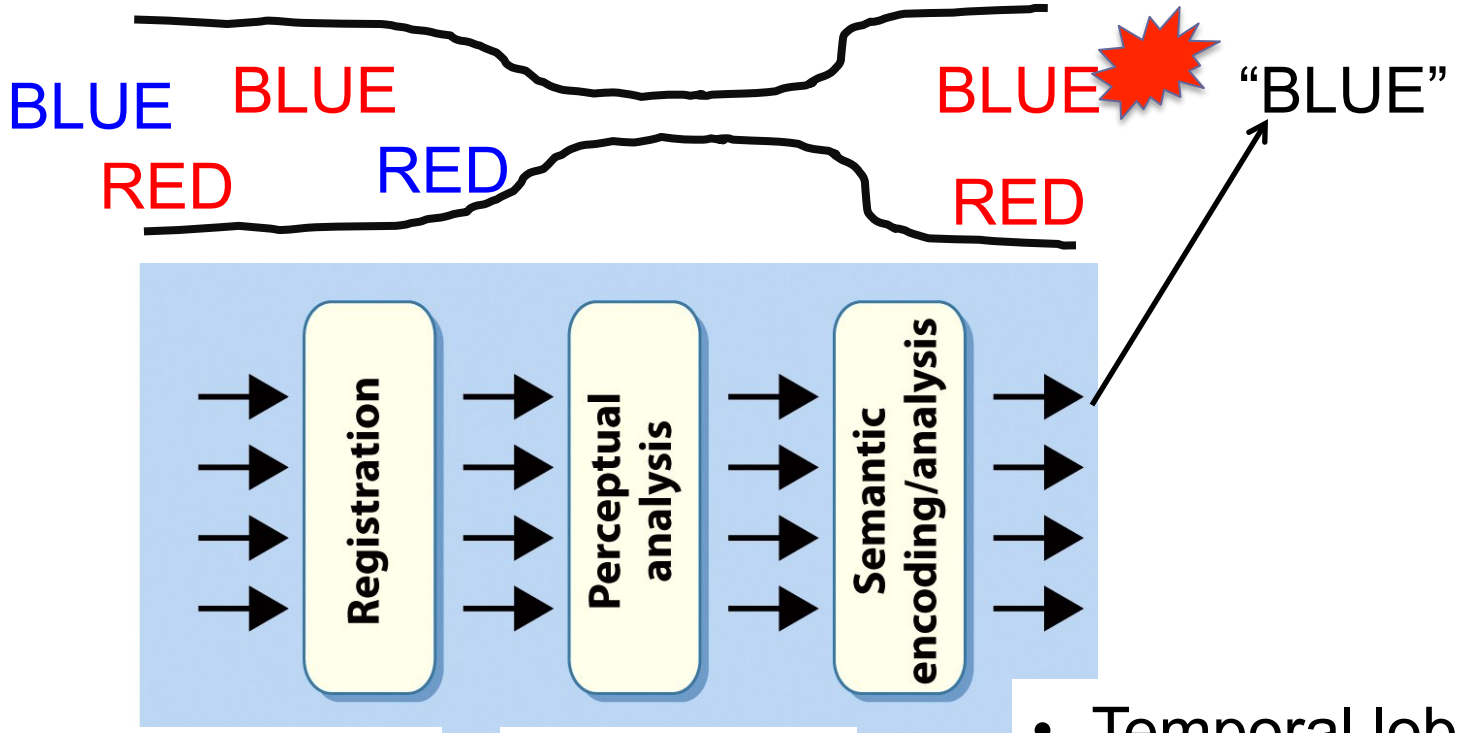


Stroop Paradigm



Why is this late selection?

Stroop effect

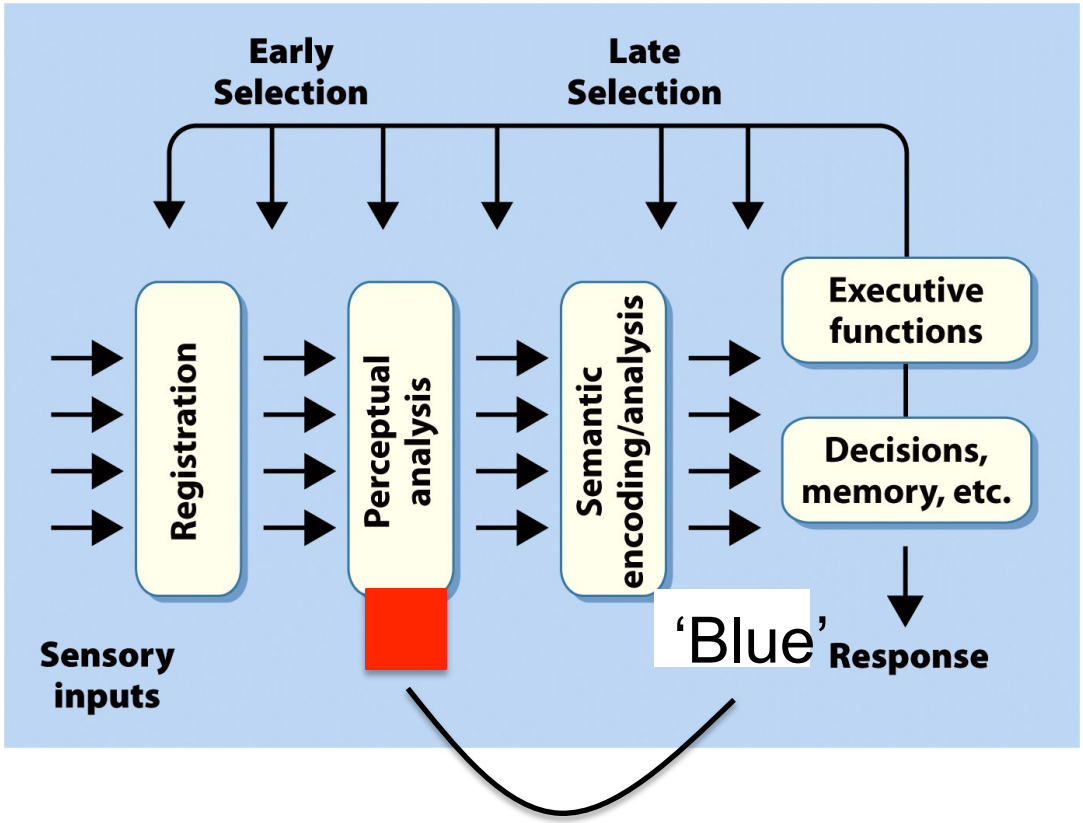


- Visual pathway
- Retina – V1
- Raw sensory inf

- V1-V4
- Feature info
- Red, lines

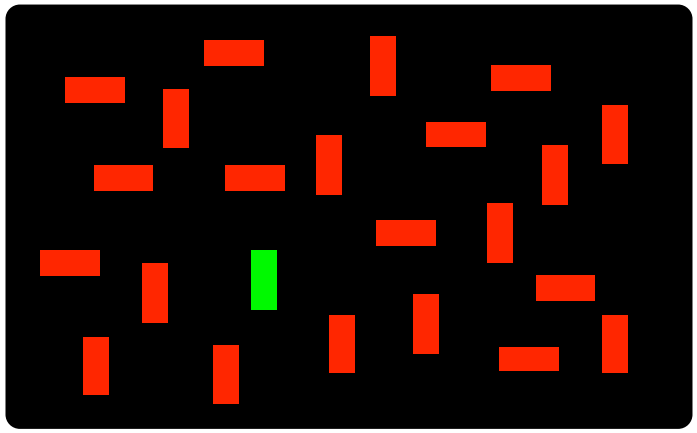
- Temporal lobe
- Recognize word as 'Blue'

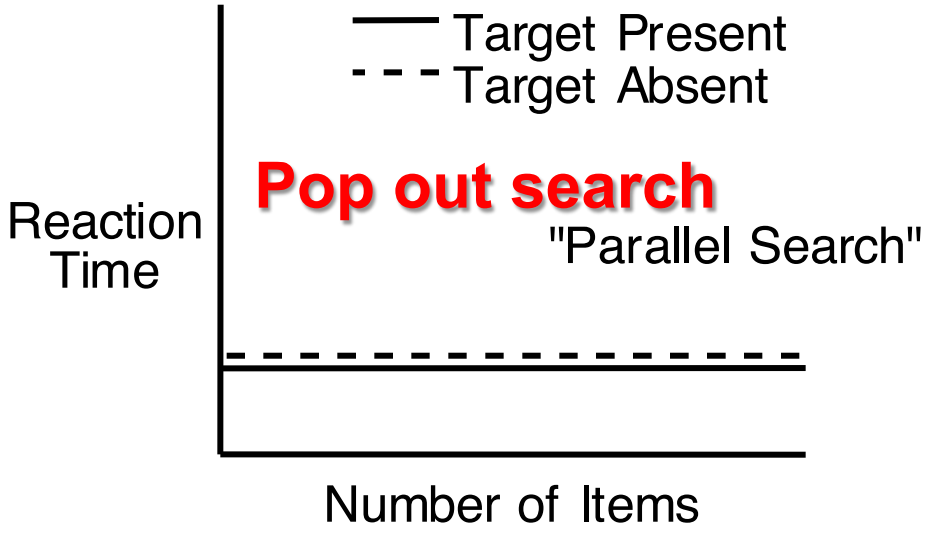
Blue

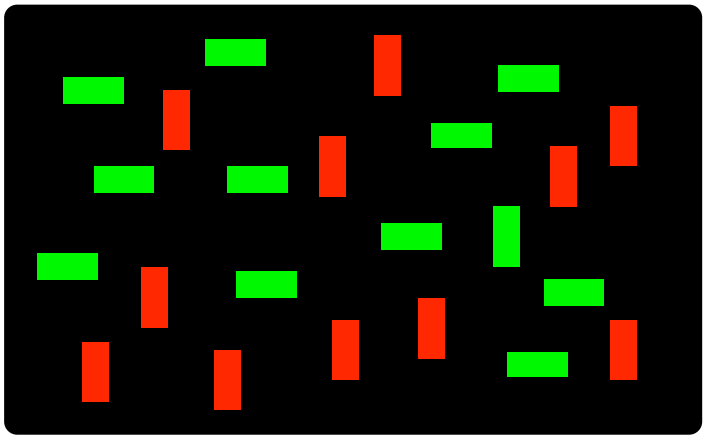


- Interference between semantic word and low level feat
- Suggests attention is still active after semantic analysis

Typical Search Results



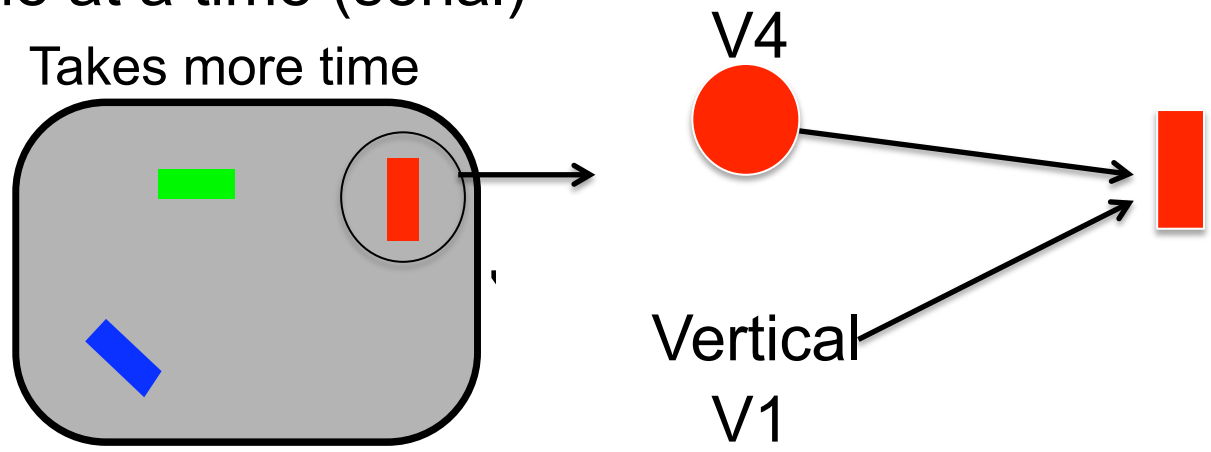




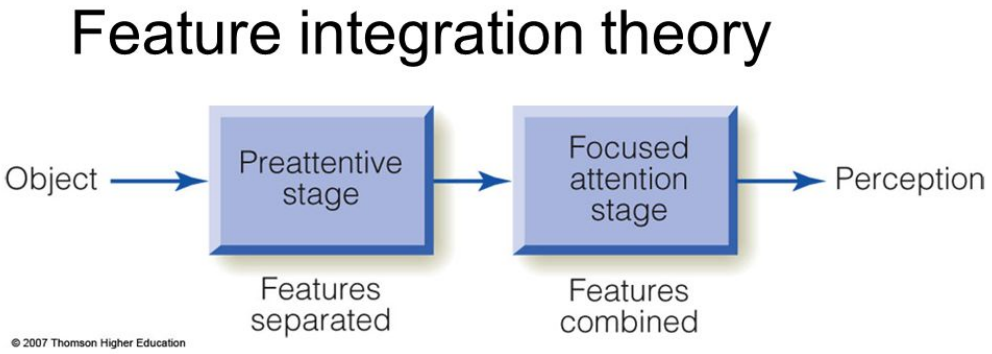
Laboratory version: Press one button for target-present and a different button for target-absent

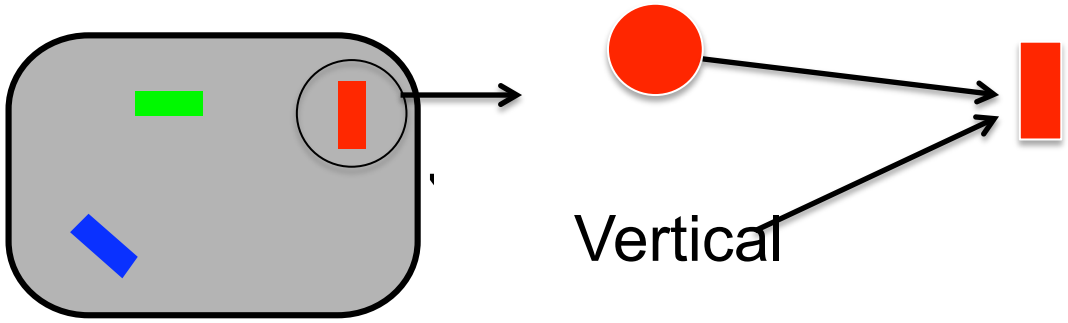
Why is conjunction search slower?

- Feature integration theory
  - Attention is needed to integrate features
  - Feature search – you do not have to attend to each stimulus
  - Conjunction search – you have to attend to each stimulus one at a time (serial)
    - Takes more time



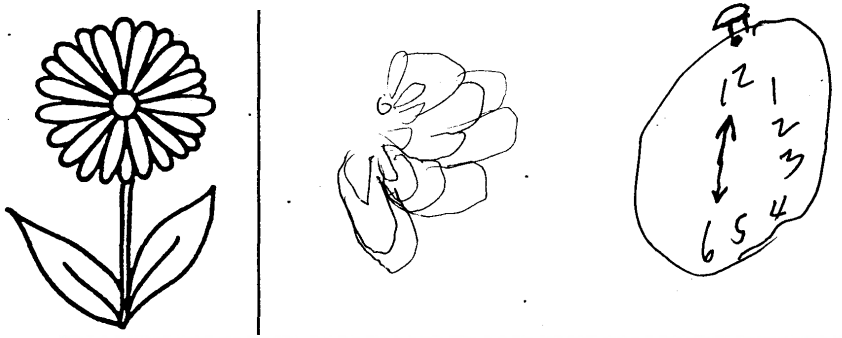
- Feature integration theory
  - Preattentive stage – features *are not* bound together
    - ‘Free floating’, separate maps…
  - Attentive stage – features *are* bound together
    - ‘Localized’, one object file

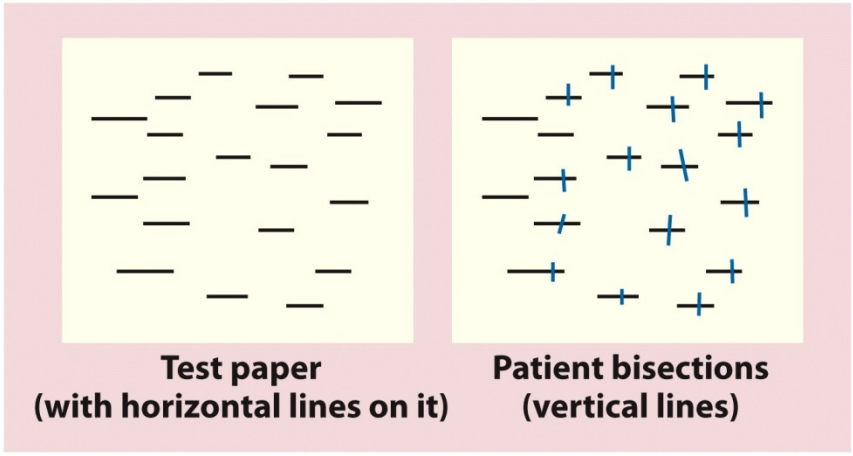


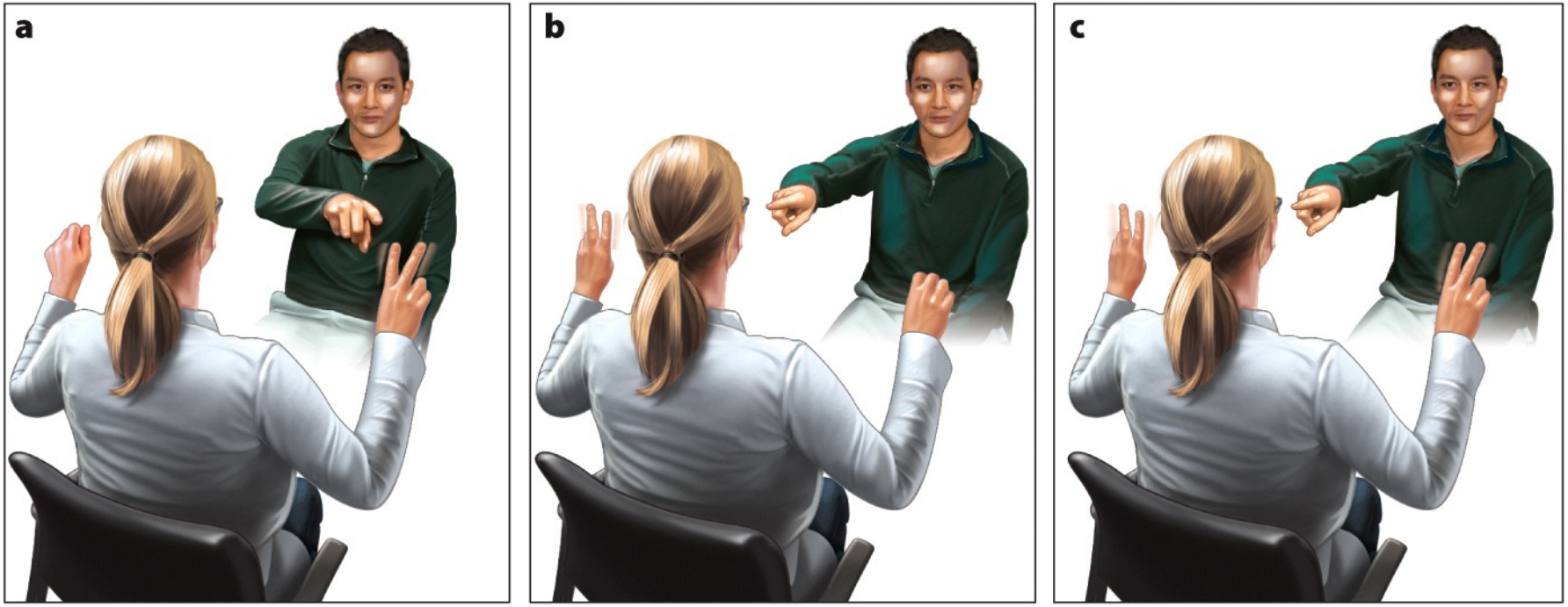


Faulty attention: Spatial neglect

- Ignore contralesional space
- Sensory perception (ability to “see”) intact
- But can direct voluntary attention to neglected side (slower though)
- Sensory-driven (reflexi very impaire







- Detect and respond (by pointing) to the stimuli if presented one at a time, suggesting no major visual field defects
- However, see only the one in the right visual field when bilateral stimuli were presented simultaneously
- **Extinction**: the simultaneous presence of the stimulus in the patient's right field leads to the stimulus on the left of the patient being extinguished from awareness